US009233565B2

(12) United States Patent
Watanabe

(10) Patent No.: US 9,233,565 B2
(45) Date of Patent: Jan. 12, 2016

(54) **APPARATUS AND NON-TRANSITORY COMPUTER-READABLE MEDIUM**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/582,831**

(22) Filed: **Dec. 24, 2014**

(65) **Prior Publication Data**

US 2015/0109361 A1 Apr. 23, 2015

Related U.S. Application Data

(62) Division of application No. 13/746,851, filed on Jan. 22, 2013, now abandoned.

(30) **Foreign Application Priority Data**

Jan. 27, 2012 (JP) 2012-015846
Jan. 27, 2012 (JP) 2012-015849
Jan. 9, 2013 (JP) 2013-001479

(51) **Int. Cl.**
B41J 29/38 (2006.01)
B41J 25/00 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***B41J 25/006*** (2013.01); ***B41J 2/07*** (2013.01); ***B41J 2/2117*** (2013.01); ***B41J 2/2132*** (2013.01)

(58) **Field of Classification Search**
CPC B41J 2/2114; B41J 2/2117; B41J 11/002; B41J 19/142; B41J 19/147
USPC 347/5, 9, 10, 12, 13, 15, 41, 43, 98, 100
See application file for complete search history.

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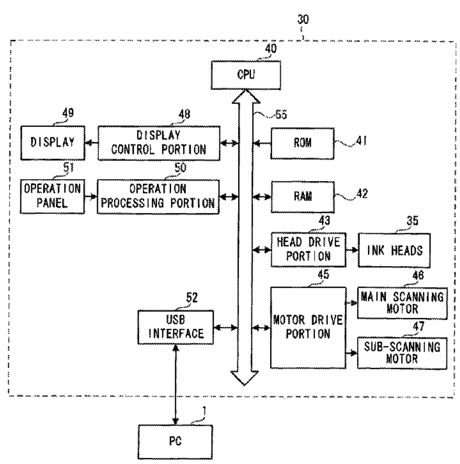
(57) **ABSTRACT**

An apparatus includes a memory storing computer-readable instructions to cause the apparatus to perform determining a scanning number of times. The scanning number of times is a number of times that a carriage of a printer is to be moved to increase a maximum density of a first ink to be higher than a unit density. The instructions also cause the apparatus to perform generating print data to cause ejection of the first and a second ink by multi-pass scans in a final printing unit. The final printing unit is continuous scans corresponding to a number of passes including a last scan, among the scans to be performed the scanning number of times. The second ink is an ink whose density is equal to or less than the unit density, among the different inks.

20 Claims, 19 Drawing Sheets



(51) **Int. Cl.**

B41J 2/07	(2006.01)
B41J 2/21	(2006.01)

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FIG. 1

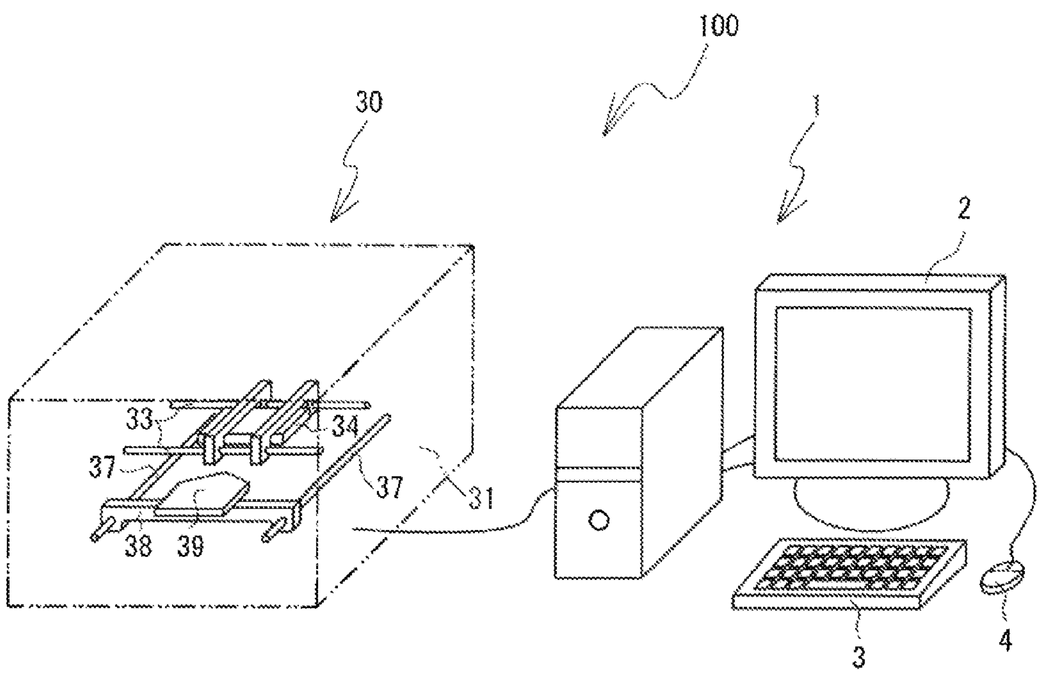


FIG. 2

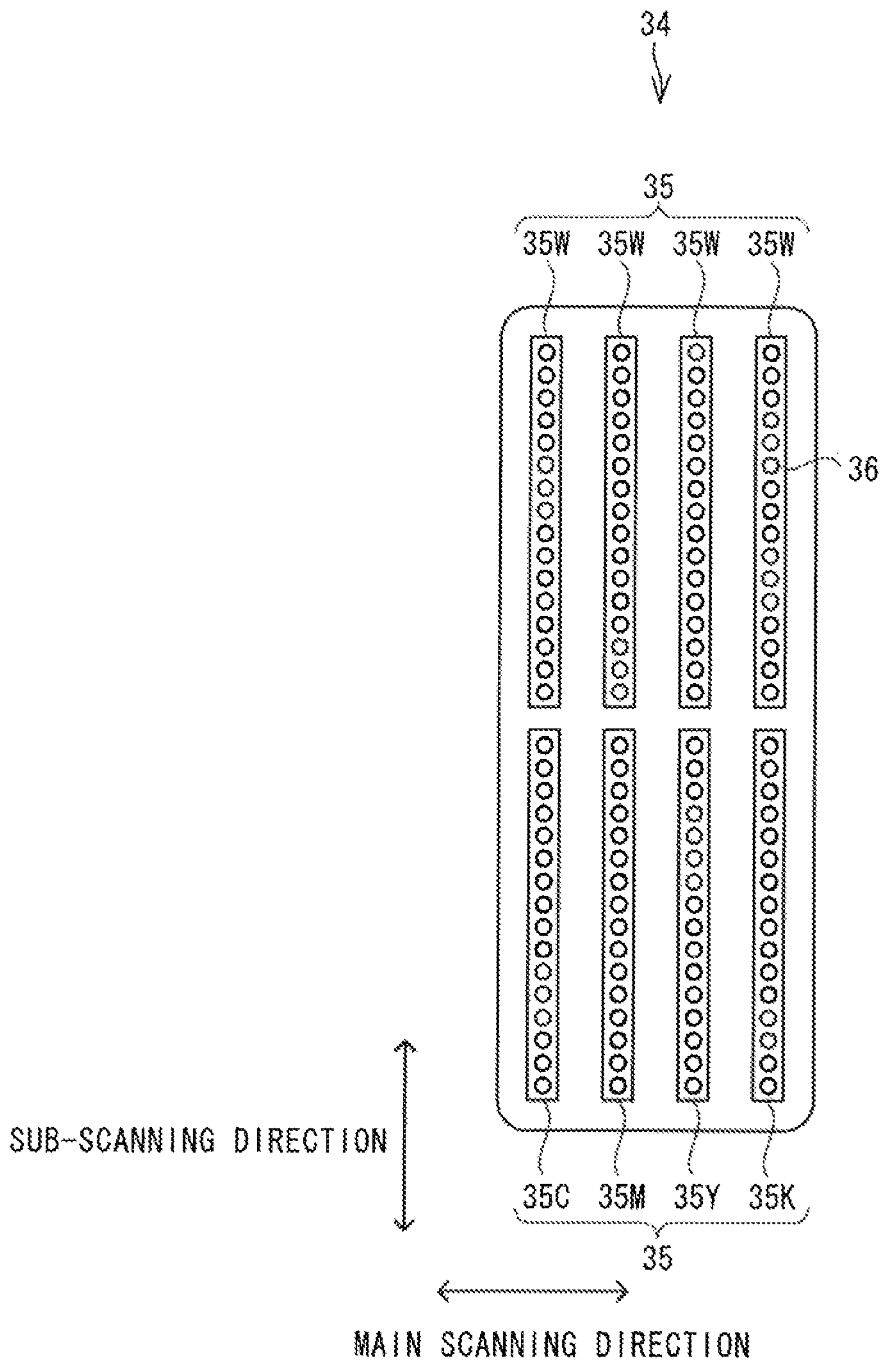

34
35
35W 35W 35W 35W
36
SUB-SCANNING DIRECTION
35C 35M 35Y 35K
35
MAIN SCANNING DIRECTION

FIG. 3

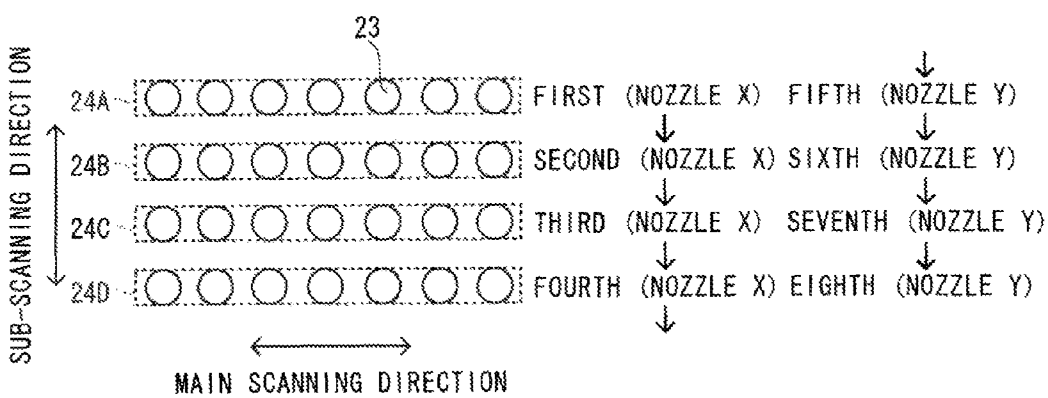

23
24A
24B
24C
24D
FIRST (NOZZLE X) FIFTH (NOZZLE Y)
SECOND (NOZZLE X) SIXTH (NOZZLE Y)
THIRD (NOZZLE X) SEVENTH (NOZZLE Y)
FOURTH (NOZZLE X) EIGHTH (NOZZLE Y)
SUB-SCANNING DIRECTION
MAIN SCANNING DIRECTION

FIG. 4

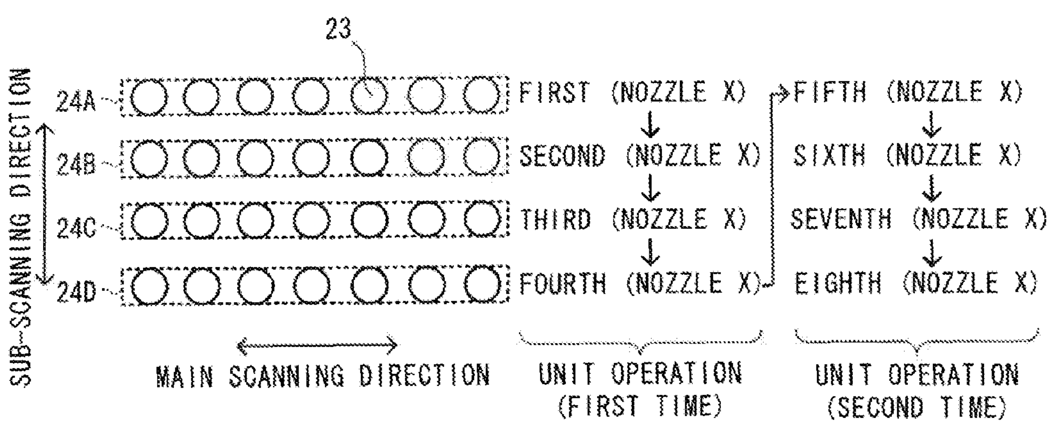

23
24A
24B
24C
24D
SUB-SCANNING DIRECTION
MAIN SCANNING DIRECTION
FIRST (NOZZLE X)
SECOND (NOZZLE X)
THIRD (NOZZLE X)
FOURTH (NOZZLE X)
FIFTH (NOZZLE X)
SIXTH (NOZZLE X)
SEVENTH (NOZZLE X)
EIGHTH (NOZZLE X)
UNIT OPERATION (FIRST TIME)
UNIT OPERATION (SECOND TIME)

FIG. 5

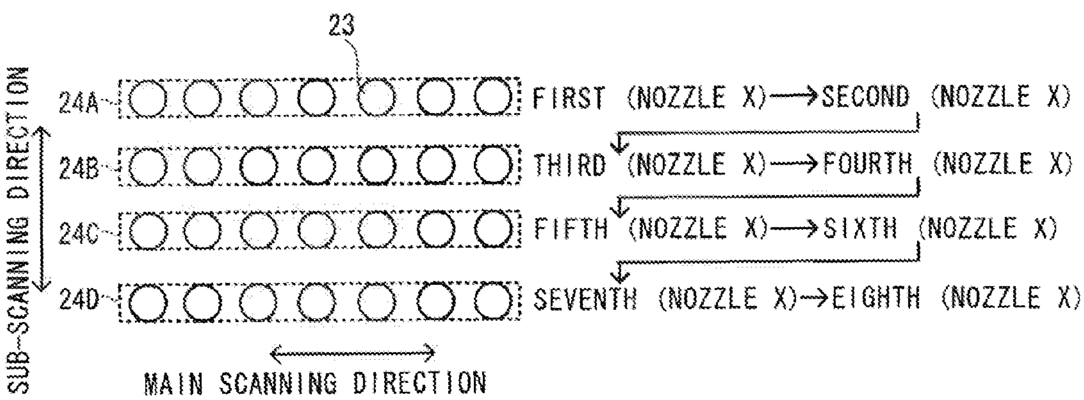

23
24A
24B
24C
24D
FIRST (NOZZLE X)→SECOND (NOZZLE X)
THIRD (NOZZLE X)→FOURTH (NOZZLE X)
FIFTH (NOZZLE X)→SIXTH (NOZZLE X)
SEVENTH (NOZZLE X)→EIGHTH (NOZZLE X)
SUB-SCANNING DIRECTION
MAIN SCANNING DIRECTION

FIG. 6

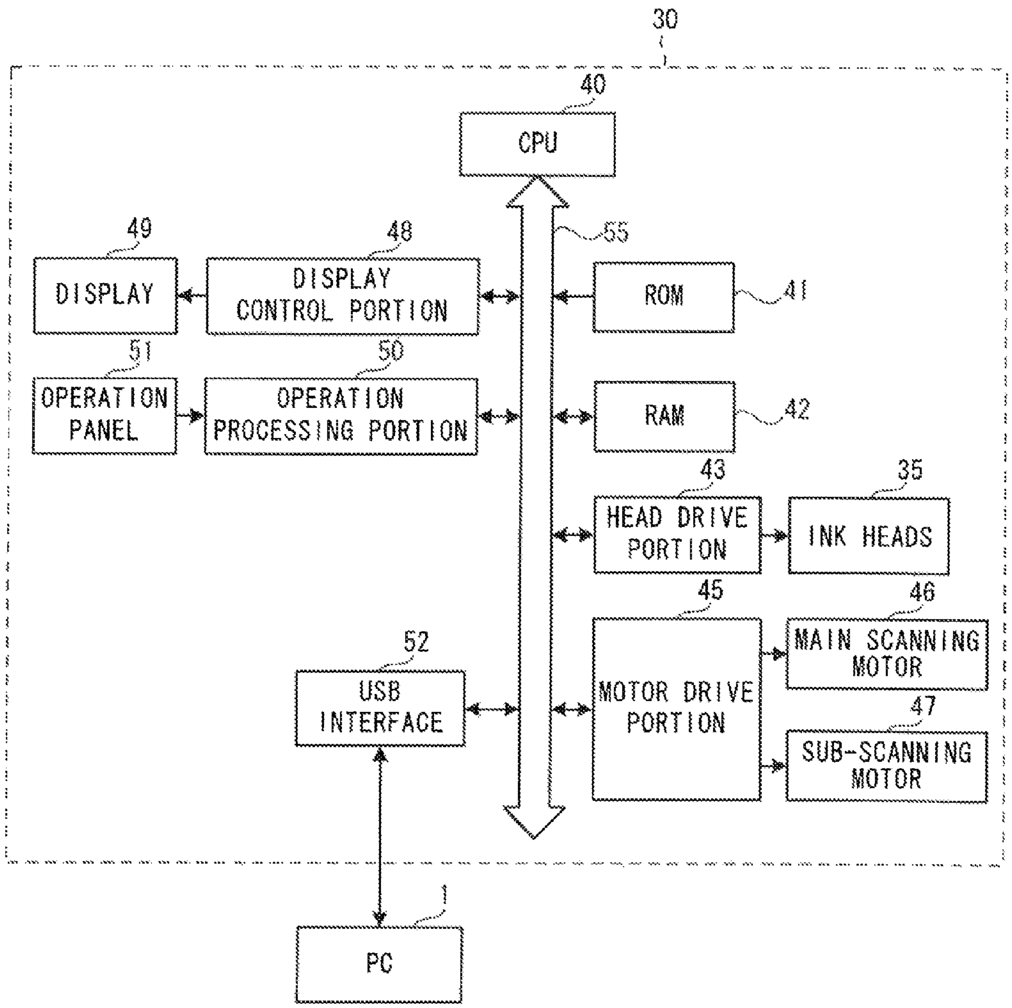

30
40
CPU
55
49
DISPLAY
48
DISPLAY CONTROL PORTION
ROM
41
51
OPERATION PANEL
50
OPERATION PROCESSING PORTION
RAM
42
43
HEAD DRIVE PORTION
35
INK HEADS
45
MOTOR DRIVE PORTION
46
MAIN SCANNING MOTOR
47
SUB-SCANNING MOTOR
52
USB INTERFACE
1
PC

FIG. 7

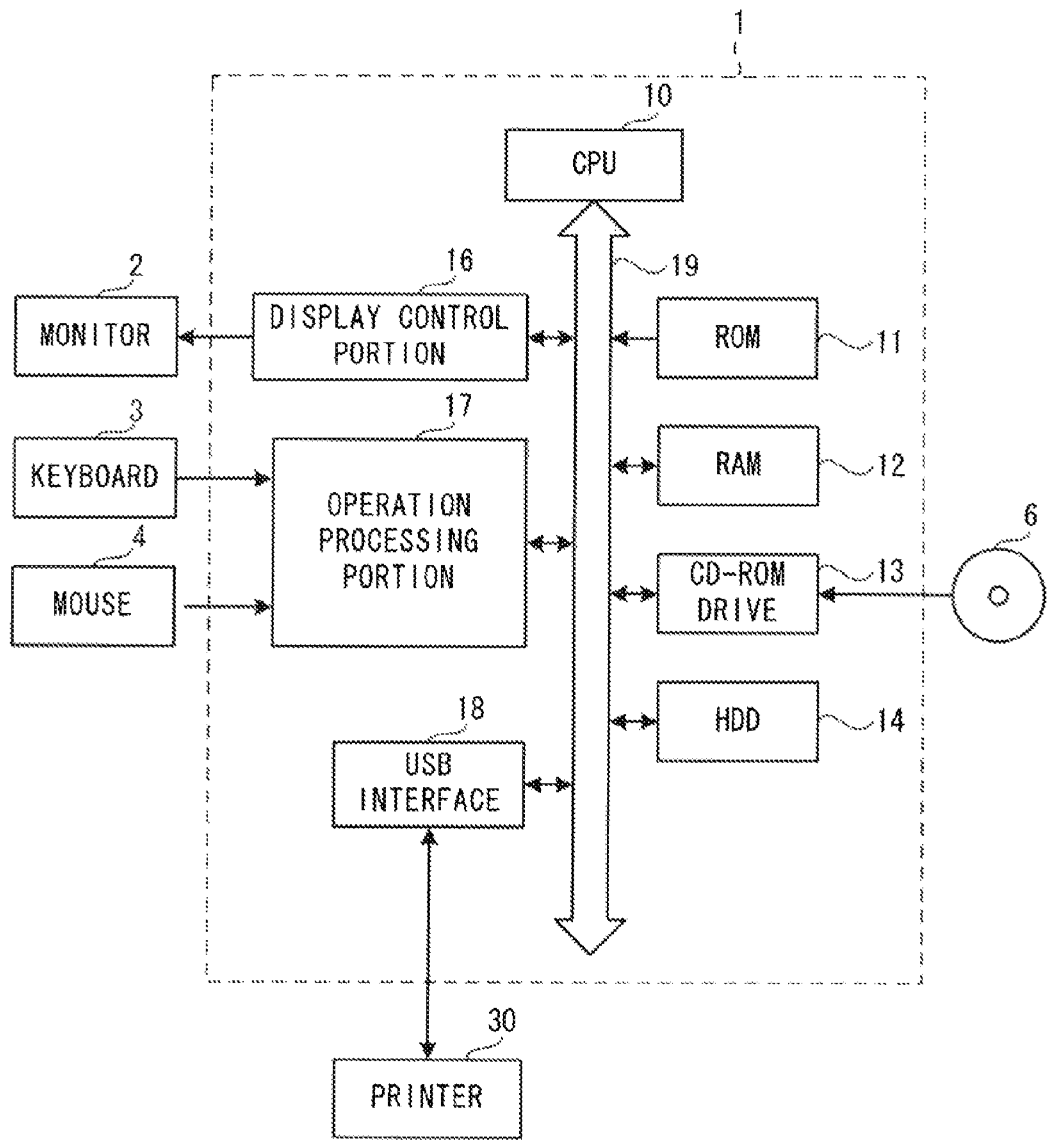

1
10
CPU
19
2
MONITOR
16
DISPLAY CONTROL PORTION
ROM
11
3
KEYBOARD
17
OPERATION PROCESSING PORTION
RAM
12
4
MOUSE
CD-ROM DRIVE
13
6
18
USB INTERFACE
HDD
14
30
PRINTER

FIG. 8

21

COLOR MODE CONVERSION TABLE							
sRGB VALUES			CMYKW VALUES				
R	G	B	C	M	Y	K	W
0	0	0	0	0	0	0	0
64	0	0	0	32	45	0	30
128	0	0	0	101	123	0	100
192	0	0	0	190	210	0	150
255	0	0	0	255	250	0	255
0	64	0	50	23	10	10	32
64	64	0	100	32	45	35	120
128	64	0	80	62	70	55	145
192	64	0	20	102	190	15	180
255	64	0	0	180	250	0	255
...	...	...	...	...	...	...	...
0	192	255	255	20	0	0	250
64	192	255	190	21	0	0	251
128	192	255	128	31	0	0	253
192	192	255	54	25	0	0	254
255	192	255	0	20	0	0	255
0	255	255	255	10	0	0	255
64	255	255	198	2	0	0	251
128	255	255	130	0	0	0	245
192	255	255	55	0	0	0	250
255	255	255	0	0	0	0	255

FIG. 9

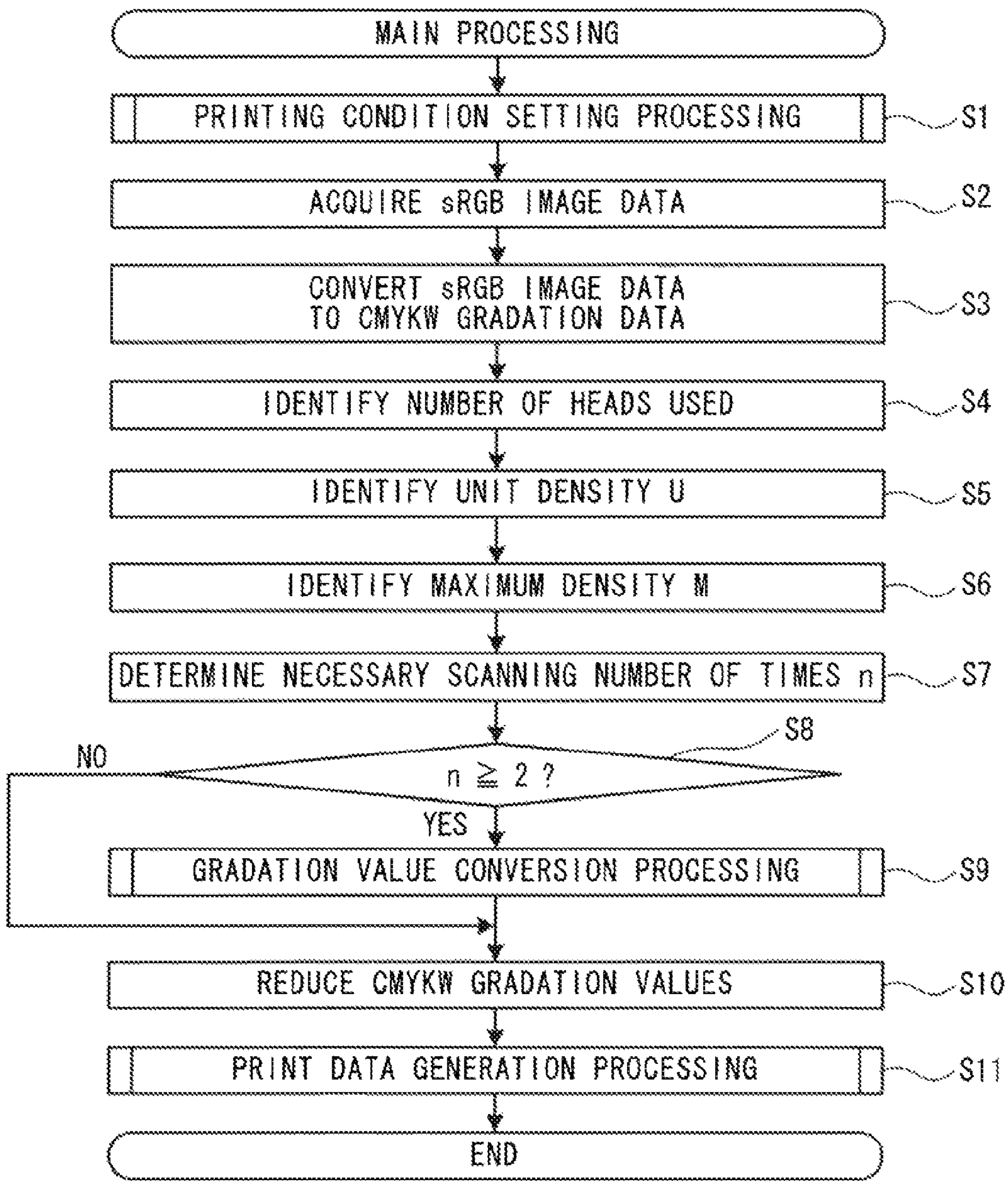

MAIN PROCESSING
PRINTING CONDITION SETTING PROCESSING
S1
ACQUIRE sRGB IMAGE DATA
S2
CONVERT sRGB IMAGE DATA TO CMYKW GRADATION DATA
S3
IDENTIFY NUMBER OF HEADS USED
S4
IDENTIFY UNIT DENSITY U
S5
IDENTIFY MAXIMUM DENSITY M
S6
DETERMINE NECESSARY SCANNING NUMBER OF TIMES n
S7
S8
n ≧ 2 ?
NO
YES
GRADATION VALUE CONVERSION PROCESSING
S9
REDUCE CMYKW GRADATION VALUES
S10
PRINT DATA GENERATION PROCESSING
S11
END

FIG. 10

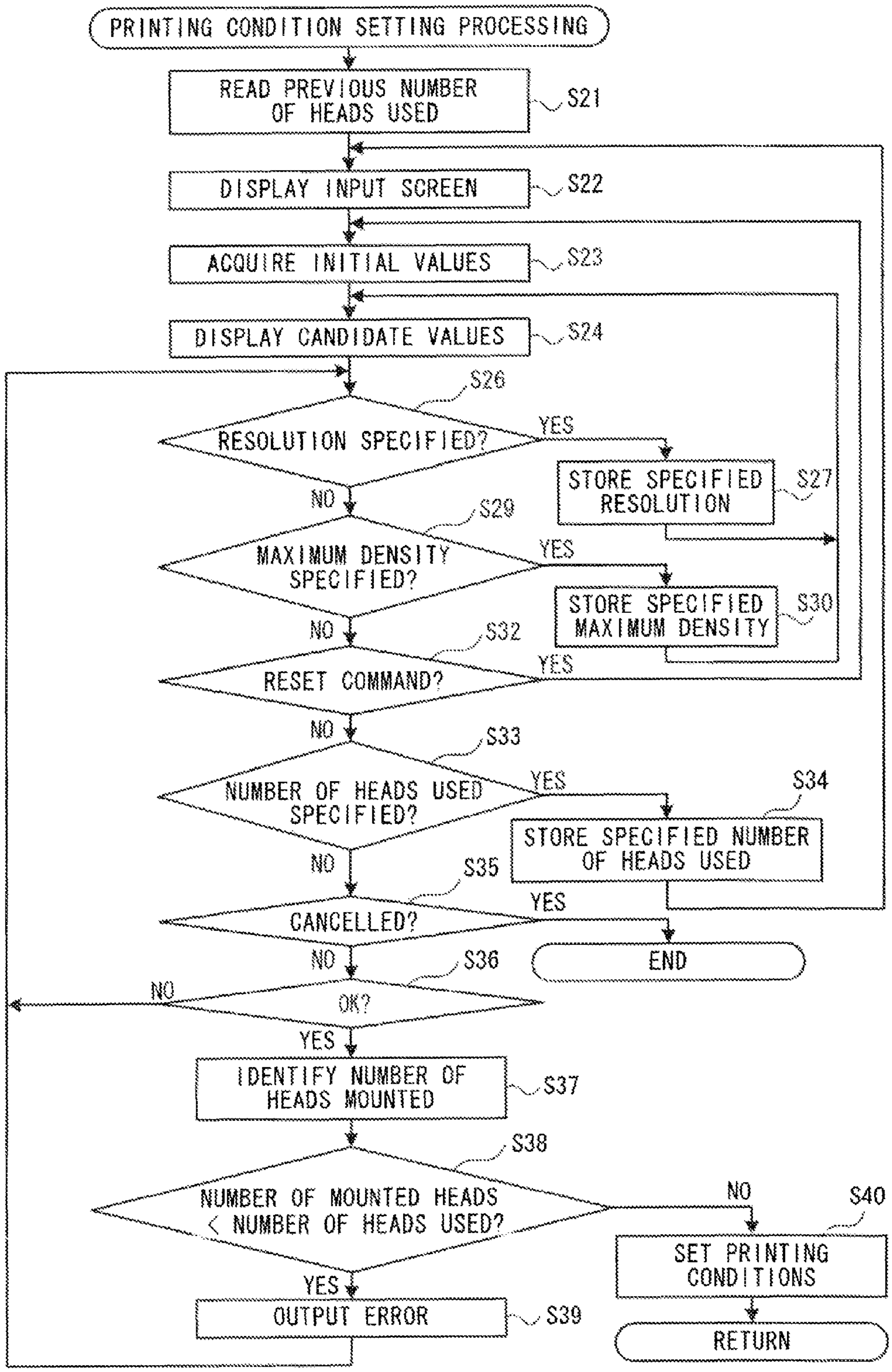

PRINTING CONDITION SETTING PROCESSING
READ PREVIOUS NUMBER OF HEADS USED
S21
DISPLAY INPUT SCREEN
S22
ACQUIRE INITIAL VALUES
S23
DISPLAY CANDIDATE VALUES
S24
S26
RESOLUTION SPECIFIED?
YES
STORE SPECIFIED RESOLUTION
S27
NO
S29
MAXIMUM DENSITY SPECIFIED?
YES
STORE SPECIFIED MAXIMUM DENSITY
S30
NO
S32
RESET COMMAND?
YES
NO
S33
NUMBER OF HEADS USED SPECIFIED?
YES
S34
STORE SPECIFIED NUMBER OF HEADS USED
NO
S35
CANCELLED?
YES
END
NO
S36
NO
OK?
YES
IDENTIFY NUMBER OF HEADS MOUNTED
S37
S38
NUMBER OF MOUNTED HEADS < NUMBER OF HEADS USED?
NO
S40
SET PRINTING CONDITIONS
RETURN
YES
OUTPUT ERROR
S39

FIG. 11

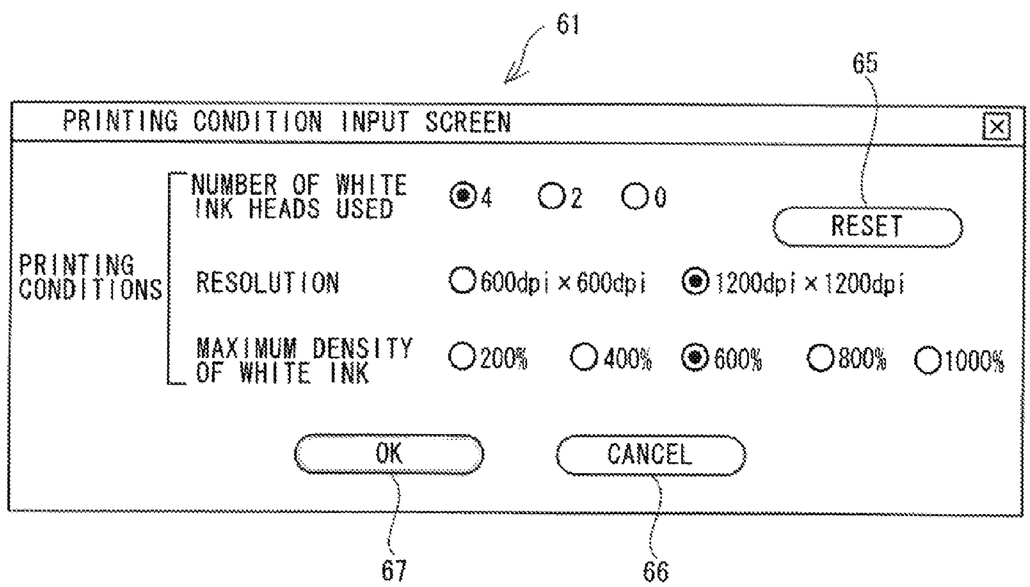

61
65
PRINTING CONDITION INPUT SCREEN
PRINTING CONDITIONS
NUMBER OF WHITE INK HEADS USED
4
2
0
RESET
RESOLUTION
600dpi × 600dpi
1200dpi × 1200dpi
MAXIMUM DENSITY OF WHITE INK
200%
400%
600%
800%
1000%
OK
CANCEL
67
66

FIG. 12

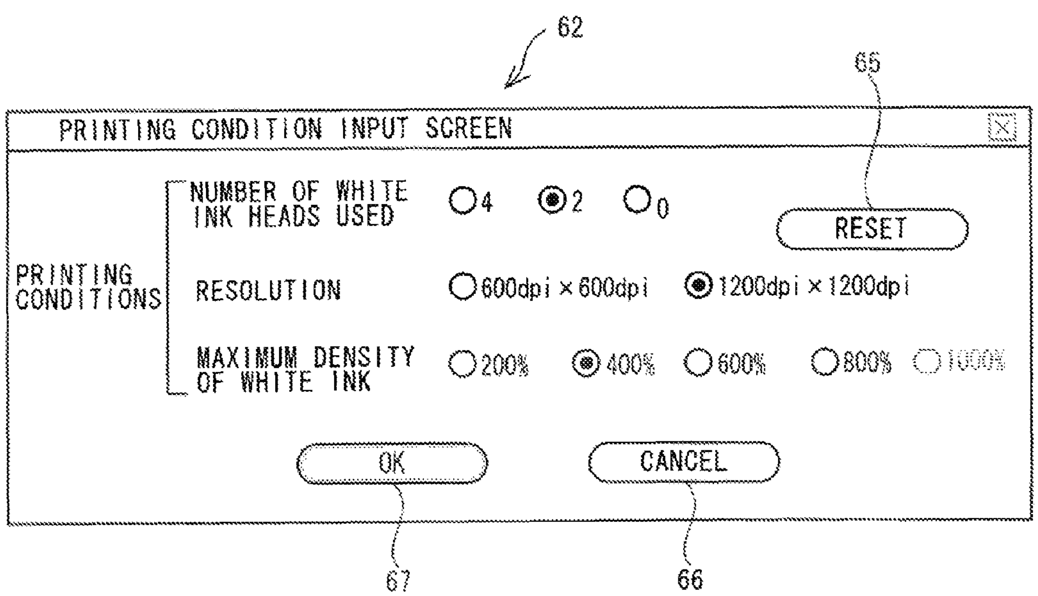

62
65
PRINTING CONDITION INPUT SCREEN
PRINTING CONDITIONS
NUMBER OF WHITE INK HEADS USED
4
2
0
RESET
RESOLUTION
600dpi × 600dpi
1200dpi × 1200dpi
MAXIMUM DENSITY OF WHITE INK
200%
400%
600%
800%
1000%
OK
CANCEL
67
66

FIG. 13

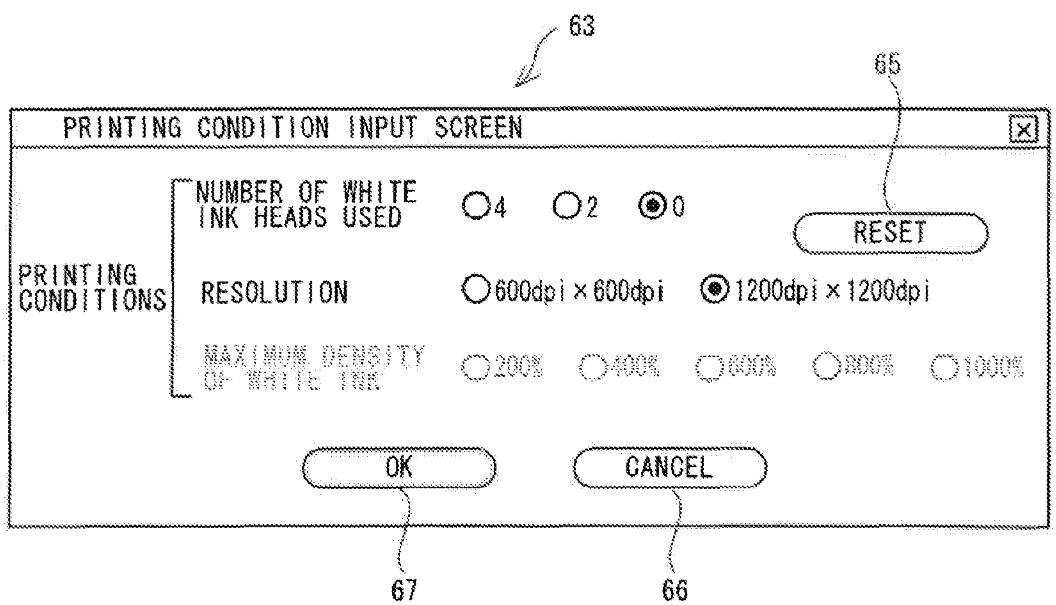

63
65
PRINTING CONDITION INPUT SCREEN
PRINTING CONDITIONS
NUMBER OF WHITE INK HEADS USED
4
2
0
RESET
RESOLUTION
600dpi × 600dpi
1200dpi × 1200dpi
MAXIMUM DENSITY OF WHITE INK
200%
400%
600%
800%
1000%
OK
CANCEL
67
66

FIG. 14

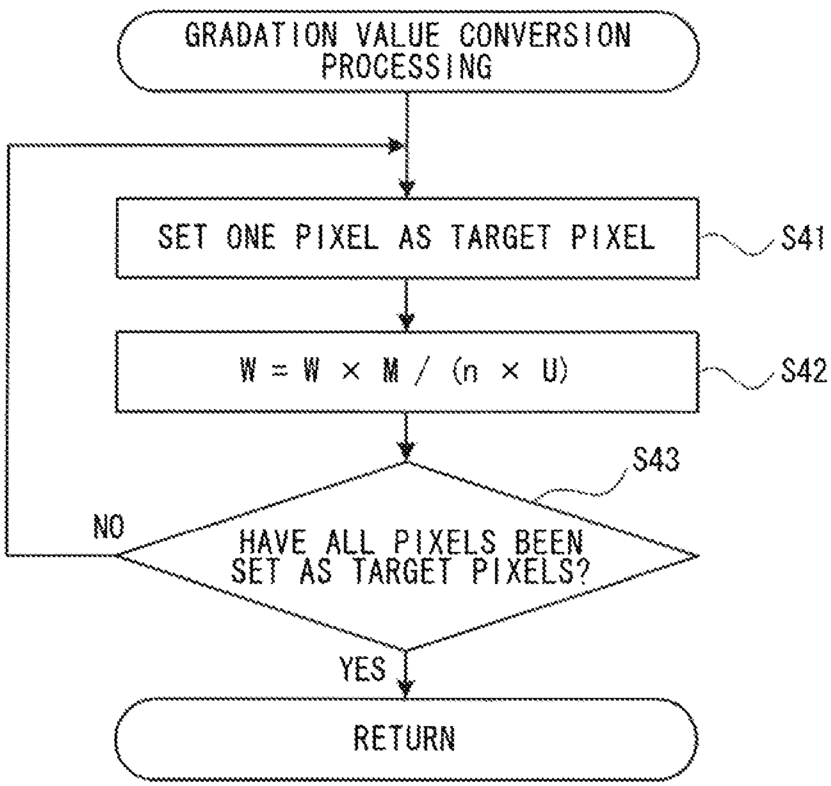

GRADATION VALUE CONVERSION PROCESSING
SET ONE PIXEL AS TARGET PIXEL
S41
W = W × M / (n × U)
S42
S43
HAVE ALL PIXELS BEEN SET AS TARGET PIXELS?
NO
YES
RETURN

FIG. 15

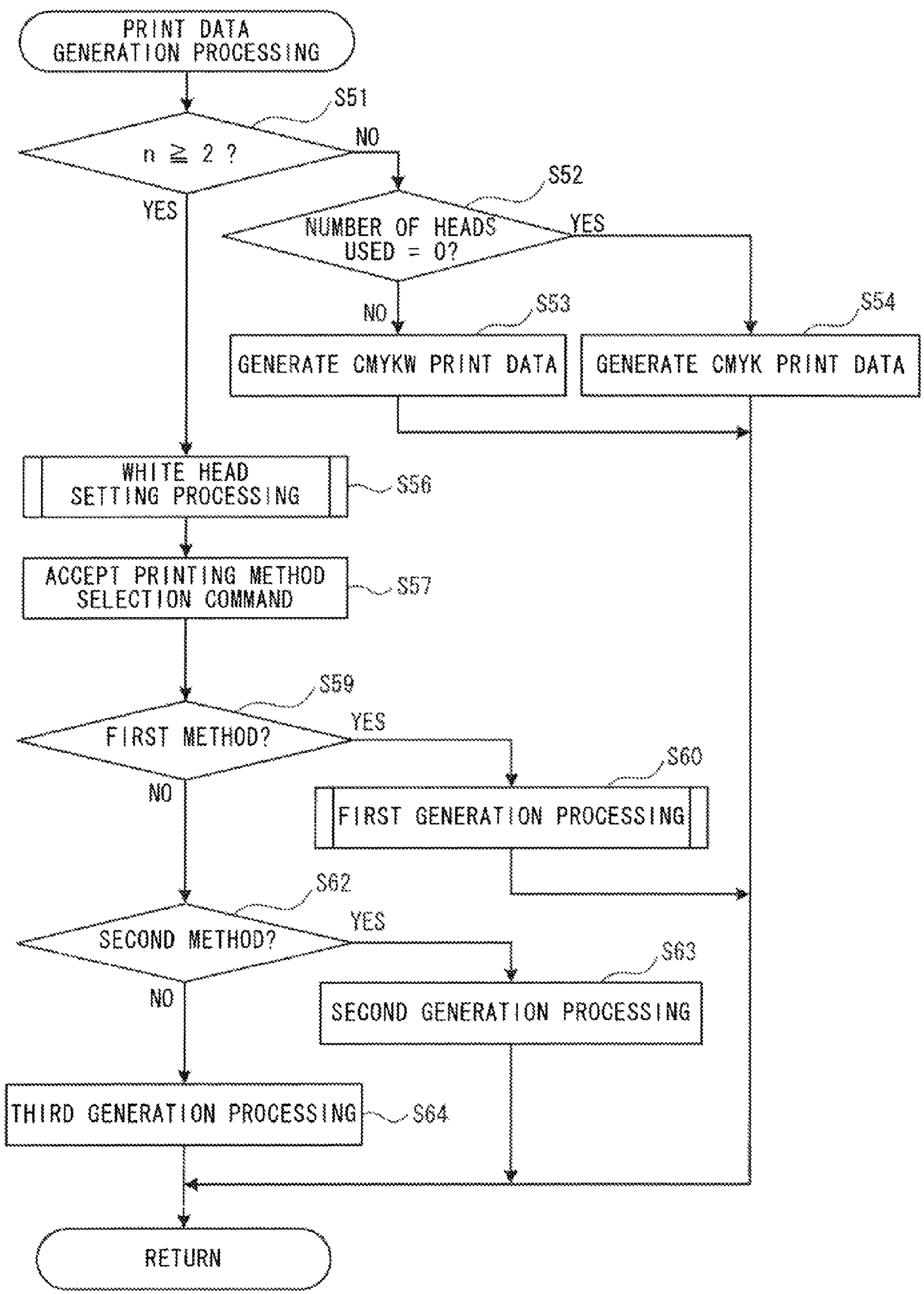

PRINT DATA GENERATION PROCESSING
S51
n ≧ 2 ?
NO
YES
S52
NUMBER OF HEADS USED = 0?
YES
NO
S53
S54
GENERATE CMYKW PRINT DATA
GENERATE CMYK PRINT DATA
WHITE HEAD SETTING PROCESSING
S56
ACCEPT PRINTING METHOD SELECTION COMMAND
S57
S59
FIRST METHOD?
YES
NO
S60
FIRST GENERATION PROCESSING
S62
SECOND METHOD?
YES
NO
S63
SECOND GENERATION PROCESSING
THIRD GENERATION PROCESSING
S64
RETURN

FIG. 16

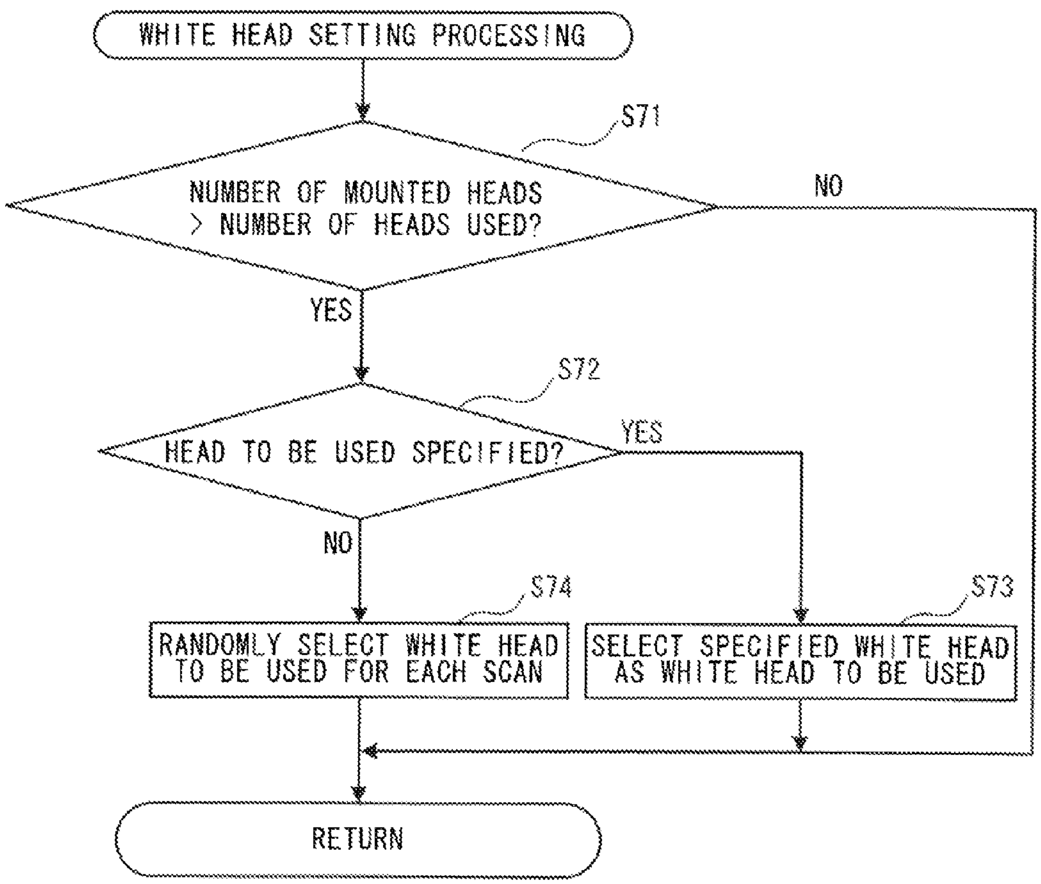
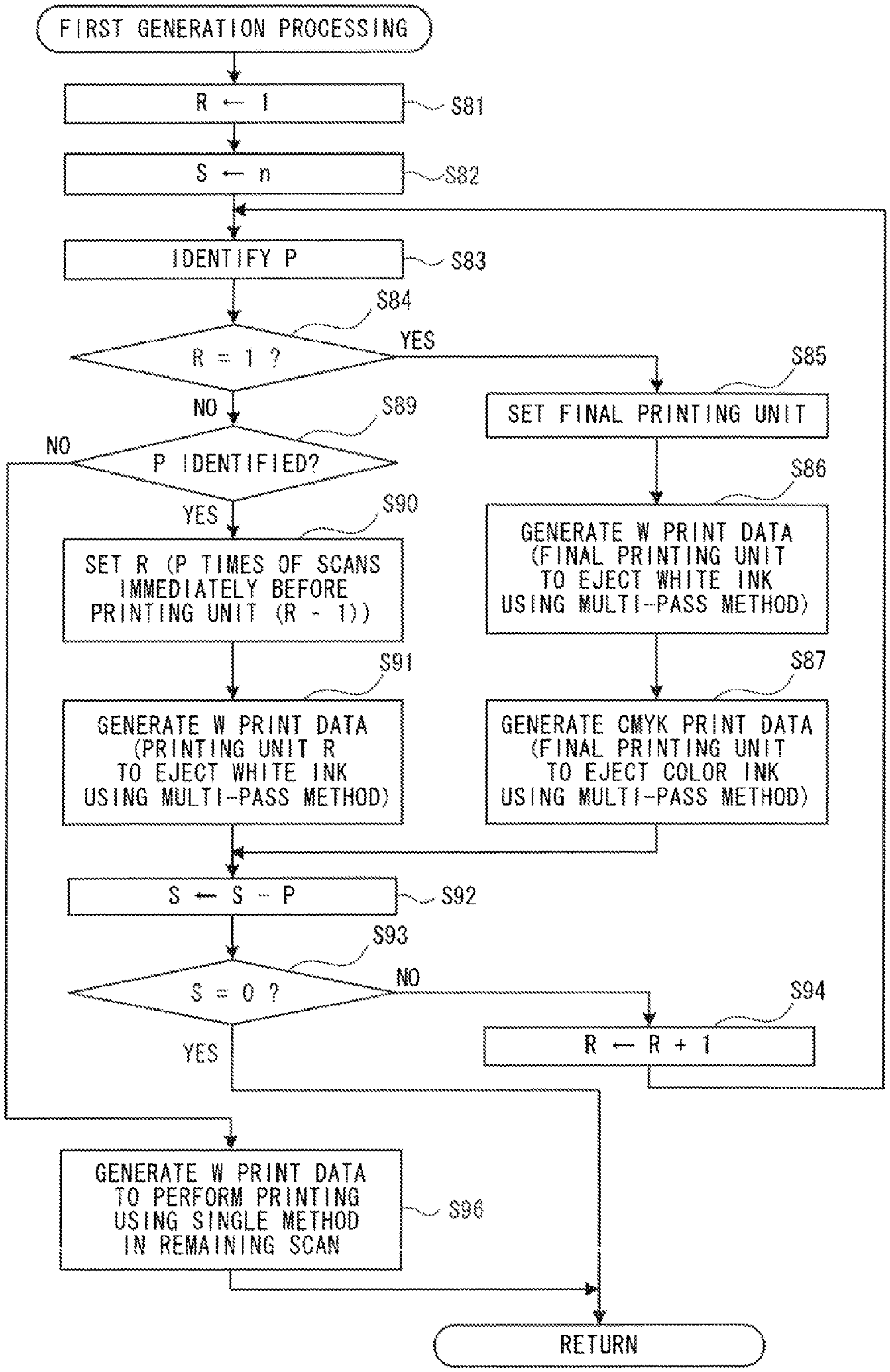

WHITE HEAD SETTING PROCESSING
S71
NUMBER OF MOUNTED HEADS
> NUMBER OF HEADS USED?
NO
YES
S72
HEAD TO BE USED SPECIFIED?
YES
NO
S74
RANDOMLY SELECT WHITE HEAD
TO BE USED FOR EACH SCAN
S73
SELECT SPECIFIED WHITE HEAD
AS WHITE HEAD TO BE USED
RETURN

FIG. 17



FIRST GENERATION PROCESSING
R ← 1
S81
S ← n
S82
IDENTIFY P
S83
S84
R = 1 ?
YES
S85
SET FINAL PRINTING UNIT
NO
S89
NO
P IDENTIFIED?
S86
YES
S90
GENERATE W PRINT DATA (FINAL PRINTING UNIT TO EJECT WHITE INK USING MULTI-PASS METHOD)
SET R (P TIMES OF SCANS IMMEDIATELY BEFORE PRINTING UNIT (R - 1))
S91
S87
GENERATE W PRINT DATA (PRINTING UNIT R TO EJECT WHITE INK USING MULTI-PASS METHOD)
GENERATE CMYK PRINT DATA (FINAL PRINTING UNIT TO EJECT COLOR INK USING MULTI-PASS METHOD)
S ← S - P
S92
S93
S = 0 ?
NO
S94
R ← R + 1
YES
GENERATE W PRINT DATA TO PERFORM PRINTING USING SINGLE METHOD IN REMAINING SCAN
S96
RETURN

FIG. 18

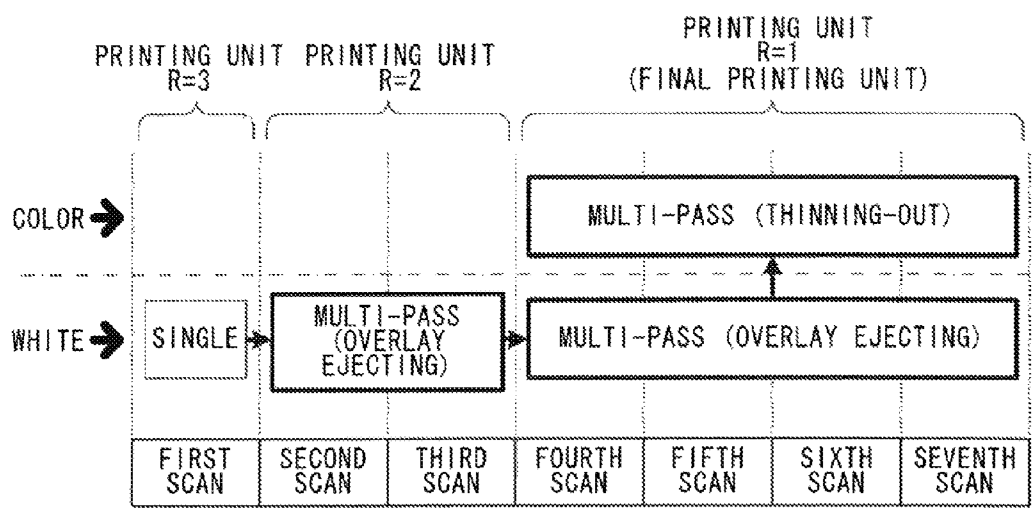
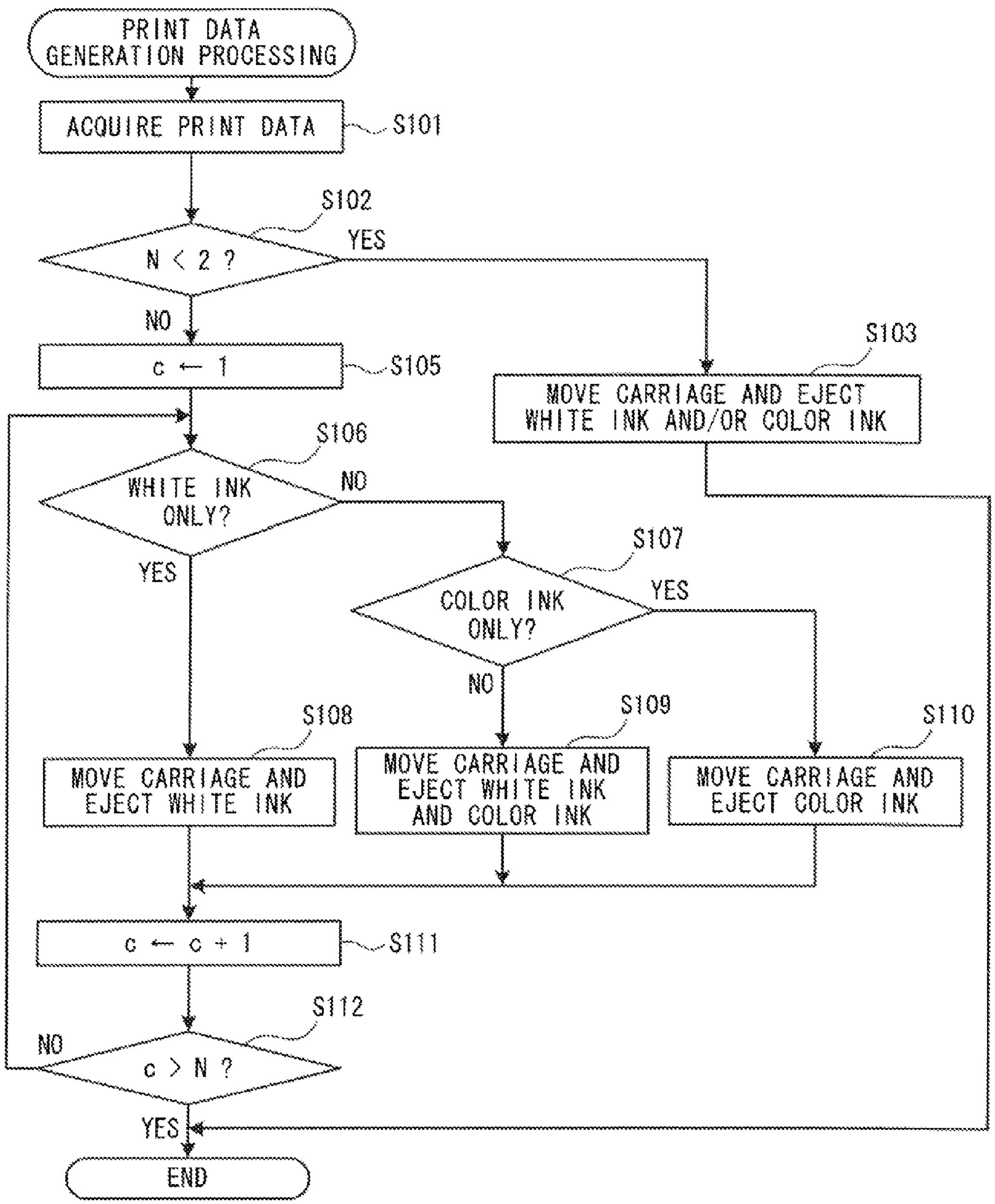

PRINTING UNIT R=3
PRINTING UNIT R=2
PRINTING UNIT R=1 (FINAL PRINTING UNIT)
COLOR
WHITE
MULTI-PASS (THINNING-OUT)
SINGLE
MULTI-PASS (OVERLAY EJECTING)
MULTI-PASS (OVERLAY EJECTING)
FIRST SCAN
SECOND SCAN
THIRD SCAN
FOURTH SCAN
FIFTH SCAN
SIXTH SCAN
SEVENTH SCAN

FIG. 19


PRINT DATA GENERATION PROCESSING
ACQUIRE PRINT DATA
S101
S102
N < 2 ?
YES
NO
c ← 1
S105
S103
MOVE CARRIAGE AND EJECT WHITE INK AND/OR COLOR INK
S106
WHITE INK ONLY?
NO
YES
S107
COLOR INK ONLY?
YES
NO
S108
MOVE CARRIAGE AND EJECT WHITE INK
S109
MOVE CARRIAGE AND EJECT WHITE INK AND COLOR INK
S110
MOVE CARRIAGE AND EJECT COLOR INK
c ← c + 1
S111
S112
NO
c > N ?
YES
END

APPARATUS AND NON-TRANSITORY COMPUTER-READABLE MEDIUM

CROSS-REFERENCE TO RELATED APPLICATION

This application is a Divisional application of U.S. Ser. No. 13/746,851, filed on Jan. 22, 2013, which claims priority to Japanese Patent Application Nos. 2012-15846 and 2012-15849 filed on Jan. 27, 2012, and also claims priority to Japanese Patent Application No. 2013-1479 filed on Jan. 9, 2013. The disclosures of the foregoing applications are herein incorporated by reference in their entirety.

BACKGROUND

The present disclosure relates to a printer and a printing method that can eject an amount of ink that is larger than an amount of the ink that can be ejected during one scan of a carriage, to each of dot arrays that extend in a main scanning direction. The present disclosure also relates to an apparatus that can generate print data.

In related art, a technique is known that causes a printer to eject ink while moving a carriage a plurality of times in order to form a dot array. For example, after performing printing using a white ink, an image forming device may perform heat fixing of the printed white ink. The image forming device may repeatedly perform printing and heat fixing of the white ink a plurality of times. In this manner, the image forming device can achieve good color development by ejecting a large amount of the white ink onto a print medium. A printing method in which printing with an ink of the same color is performed by moving a carriage a plurality of times for each of the dot arrays will be hereinafter referred to as overprinting.

SUMMARY

When a known print data generation device causes a printer to perform overprinting, the device generates print data for each scan. Therefore, as compared to a case in which overprinting is not performed, a processing load on the print data generation device may increase and the amount of the print data may also increase. As a result, in the related art, there may be cases in which processing cannot be performed efficiently when overprinting is performed.

Embodiments provide an apparatus that includes a control portion and a memory configured to store computer-readable instructions. When executed by the control portion, the computer-readable instructions cause the apparatus to perform a step of determining a scanning number of times. The scanning number of times is a number of times that a carriage of a printer is to be moved in a main scanning direction to increase a maximum density of a first ink to be higher than a unit density. The carriage is mounted with a plurality of ink heads that are respectively configured to eject different inks including the first ink. The unit density is a density of a maximum amount of ink that can be ejected by moving the carriage once with respect to a dot array extending in the main scanning direction.

The computer-readable instructions also cause the apparatus to perform a step of generating, in a case where the scanning number of times is larger than a minimum value of a number of passes that can be set, print data to cause ejection of the first ink and ejection of a second ink to be performed by multi-pass scans in a final printing unit, among a plurality of scans to be performed the scanning number of times. The multi-pass scans is a plurality of scans in which, every time a scan is performed, an ink is ejected to the dot array from a nozzle different from a nozzle used in a preceding scan, among a plurality of nozzles provided on each of the plurality of ink heads. The number of passes is a number of scans included the multi-pass scans. The final printing unit is continuous scans corresponding to the number of passes including a last scan, among the scans to be performed the scanning number of times. The second ink is an ink whose density is equal to or less than the unit density, among the different inks.

Embodiments also provide a non-transitory computer-readable medium storing computer-readable instructions. When executed by a processor of a computer, the computer-readable instructions cause the computer to perform a determination operation determining a scanning number of times. The scanning number of times is a number of times that a carriage of a printer is to be moved in a main scanning direction to increase a maximum density of a first ink to be higher than a unit density. The carriage is mounted with a plurality of ink heads that are respectively configured to eject different inks including the first ink. The unit density is a density of a maximum amount of ink that can be ejected by moving the carriage once with respect to a dot array extending in the main scanning direction.

The computer-readable instructions also cause the computer to perform a generation operation, in a case where the scanning number of times is larger than a minimum value of a number of passes that can be set, print data to cause ejection of the first ink and ejection of a second ink to be performed by multi-pass scans in a final printing unit, among a plurality of scans to be performed the scanning number of times. The multi-pass scans is a plurality of scans in which, every time a scan is performed, an ink is ejected to the dot array from a nozzle different from a nozzle used in a preceding scan, among a plurality of nozzles provided on each of the plurality of ink heads. The number of passes is a number of scans included the multi-pass scans. The final printing unit is continuous scans corresponding to the number of passes including a last scan, among the scans to be performed the scanning number of times. The second ink is an ink whose density is equal to or less than the unit density, among the different inks.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments will be described below in detail with reference to the accompanying drawings in which:

FIG. **1** is a perspective view showing an outline of a printing system;

FIG. **2** is a bottom plan view of a carriage;

FIG. **3** is an explanatory diagram illustrating a first method of overprinting:

FIG. **4** is an explanatory diagram illustrating a second method of overprinting;

FIG. **5** is an explanatory diagram illustrating a third method of overprinting;

FIG. **6** is a block diagram showing an electrical configuration of a printer;

FIG. **7** is a block diagram showing an electrical configuration of a personal computer (PC);

FIG. **8** is a data structure diagram of a color mode conversion table;

FIG. **9** is a flowchart of main processing that is performed by the PC;

FIG. **10** is a flowchart of printing condition setting processing that is performed in the main processing:

FIG. **11** is a diagram showing a printing condition input screen (an initial screen) when the number of heads used is 4;

FIG. **12** is a diagram showing a printing condition input screen (an initial screen) when the number of heads used is 2;

FIG. **13** is a diagram showing a printing condition input screen (an initial screen) when the number of heads used is 0;

FIG. **14** is a flowchart of gradation value conversion processing that is performed in the main processing;

FIG. **15** is a flowchart of print data generation processing that is performed in the main processing:

FIG. **16** is a flowchart of white head setting processing, which is performed in the print data generation processing;

FIG. **17** is a flowchart of first generation processing that is performed in the print data generation processing;

FIG. **18** is an explanatory diagram illustrating a printing operation that is performed when a necessary scanning number of times is seven; and

FIG. **19** is a flowchart of print processing that is performed by the printer.

DETAILED DESCRIPTION

Hereinafter, an embodiment will be explained with reference to the drawings. A printing system **100** that includes a personal computer (hereinafter simply referred to as PC) **1** and a printer **30** will be explained with reference to FIG. **1**. The printer **30** is a known inkjet printer for fabrics. The printer **30** is configured to eject ink while moving ink heads **35** (refer to FIG. **2**), and thereby performing printing on a fabric, which is a print medium. The PC **1** can generate print data to cause the printer **30** to perform printing.

An outline of the printer **30** will be explained with reference to FIG. **1** and FIG. **2**. The lower left side and the upper right side of FIG. **1** respectively correspond to the front side and the back side of the printer **30**. The left-right direction and the up-down direction of FIG. **1** respectively correspond to the left-right direction and the up-down direction of the printer **30**. As shown in FIG. **1**, the printer **30** includes a housing **31** having a rectangular box shape. A pair of guide rails **33** extend in the left-right direction, substantially in the center of the housing **31** in the front-rear direction. A carriage **34** is supported by the guide rails **33** such that the carriage **34** can move in the left-right direction (a main scanning direction) along the guide rails **33**. Hereinafter, a movement of the ink heads **35** or the carriage **34** in the main scanning direction is also referred to a scan. Although not shown in detail in the drawings, the carriage **34** is configured such that the carriage **34** can be moved in the main scanning direction by a main scanning mechanism. The main scanning mechanism includes a main scanning motor **46** (refer to FIG. **6**) and a belt. The plurality of ink heads **35** (refer to FIG. **2**) are provided on a lower portion of the carriage **34**. An arrangement of the ink heads **35** will be described later with reference to FIG. **2**.

A pair of guide rails **37** that extend in the front-rear direction are provided inside the housing **31**, in a substantially central lower portion of the housing **31** in the left-right direction. A platen support **38** is supported by the guide rails **37** such that the platen support **38** can move in the front-rear direction (a sub-scanning direction) along the guide rails **37**. Although not shown in detail in the drawings, the platen support **38** is configured such that the platen support **38** can be moved in the sub-scanning direction by a sub-scanning mechanism. The sub-scanning mechanism includes a sub-scanning motor **47** (refer to FIG. **6**) and a belt. A replaceable platen **39** is fixed to substantially the center, in the left-right direction, of a top surface of the platen support **38**. The platen **39** is a plate member having a substantially pentagonal shape in a plan view. A fabric, such as a t-shirt, may be placed on a top surface of the platen **39**.

The printer **30** can form dot arrays extending in the main scanning direction by ejecting ink while moving the ink heads **35** in the main scanning direction. When one or more scans in the main scanning direction are complete, the printer **30** moves the platen **39** in the sub-scanning direction. After that, the printer **30** forms dot arrays extending in the main scanning direction again, in the same manner as described above. The printer **30** performs printing by repeatedly performing the above-described operations in accordance with the print data and forming a plurality of dot arrays on the print medium.

The printer **30** of the present embodiment is configured to move the carriage **34** in the main scanning direction and to move the platen **39** in the sub-scanning direction. Thus, the printer **30** can relatively move the carriage **34** and the print medium held by the platen **39**. The sub-scanning direction (the front-rear direction of the printer **30**, in the present embodiment) is a direction orthogonal to the main scanning direction (the left-right direction of the printer **30**, in the present embodiment). A method for relatively moving the carriage **34** and the print medium is not limited to the method of the present embodiment. For example, the platen **39** may be moved in the main scanning direction and the carriage **34** may be moved in the sub-scanning direction. Alternatively, just the platen **39** may be moved in the main scanning direction and the sub-scanning direction, or just the carriage **34** may be moved in the main scanning direction and the sub-scanning direction. When just the platen **39** is moved, the carriage **34** only holds the ink heads **35** and does not move. The print medium may be moved using a roller or the like instead of the platen **39**.

The structure of the carriage **34** will be explained. As shown in FIG. **2**, the plurality of ink heads **35** are mounted on the carriage **34** of the present embodiment. A plurality of fine nozzles **36** are provided in a bottom portion of each of the ink heads **35**. Each of the nozzles **36** has an ejection port that opens in the bottom surface of each of the ink heads **35**. In the present embodiment, the number of the nozzles **36** that are actually provided on each of the ink heads **35** is 128. However, the number of the nozzles **36** in FIG. **2** has been reduced in order to simplify the drawing. The ink supplied from ink cartridges (not shown in the drawings) to the ink heads **35** may be ejected downward from the ejection ports of the nozzles **36** by driving of piezoelectric elements. The plurality of nozzles **36** on each of the ink heads **35** are arranged side by side in a direction (the sub-scanning direction in the present embodiment) that intersects with the main scanning direction.

The printer **30** of the present embodiment can perform printing by ejecting both a white ink and a color ink (i.e. an ink whose color is different from white) to the print medium while the carriage **34** is moved in the main scanning direction. More specifically, the printer **30** of the present embodiment can perform simultaneous printing of white and color by using the carriage **34** shown in FIG. **2**. Therefore, the printer **30** can complete printing in a relatively short time. Both white ink heads **35**W and color ink heads **35**C, **35**M, **35**Y and **35**K are mounted on the carriage **34**. Hereinafter, the color ink heads **35**C, **35**M, **35**Y and **35**K are also collectively referred to as color ink heads **35**CL.

The white ink heads **35**W are each configured to eject the white ink. The color ink head **35**C is configured to eject a cyan ink. The color ink head **35**M is configured to eject a magenta ink. The color ink head **35**Y is configured to eject a yellow ink. The color ink head **35**K is configured to eject a black ink.

That is, the ejection ports of the 128 nozzles **36** that are provided on each of the ink heads **35** form an ejection port array that is configured to eject an ink of the same color. In the example shown in FIG. **2**, the four white ink heads **35**W are arranged side by side in the main scanning direction. Further, the four color ink heads **35**C, **35**M, **35**Y and **35**K are arranged side by side in the main scanning direction, in positions displaced from the four white ink heads **35**W in the sub-scanning direction.

In the present embodiment, a plurality of ejection ports that are configured to eject an ink of the same color is defined as an ejection port group. The four ejections port arrays of the white ink heads **35**W arranged side by side in the main scanning direction form an ejection port group for the white ink. The ejection port army of the color ink head **35**C forms an ejection port group for the cyan ink. The ejection port array of the color ink head **35**M forms an ejection port group for the magenta ink. The ejection port array of the color ink head **35**Y forms an ejection port group for the yellow ink. The ejection port array of the color ink head **35**K forms an ejection port group for the black ink.

When print processing is performed by the printer **30**, the color inks are ejected onto the white ink. During printing, the platen **39** (refer to FIG. **1**) moves to the lower side in FIG. **2** with respect to the carriage **34**. That is, the feed direction of the platen **39** is a direction heading from the upper side toward the lower side in FIG. **2** along the sub-scanning direction. The white ink heads **35**W are arranged on an upstream side of the color ink heads **35**CL in the feed direction of the platen **39**. Note that the white ink heads **35**W and the color ink heads **35**C, **35**M, **35**Y and **35**K may be in contact with or separated from each other.

In the present embodiment, one ejection port array that can eject an ink of the same color is provided on each one of the ink heads **35**. The ejection port group for the white ink is provided on a plurality of ink heads **35** and each of the ejection port groups for cyan, magenta, yellow and black is provided on one ink head **35**. However, the correspondence relationship between the ink heads **35** and the ejection port arrays as well as the correspondence relationship between the ink heads **35** and the ejection port groups are not limited to this example. For example, a plurality of ejection port arrays that can respectively eject different color inks may be provided on one ink head **35**. For example, in the example shown in FIG. **2**, one of the white ink heads **35**W located on the upstream side in the feed direction of the platen **39** and one of the color ink heads **35**CL located on the downstream side may be integrated into one ink head. Specifically, the nozzles **36** of the white ink head **35**W that is located at the left end and the nozzles **36** of the color ink head **35**C that is located at the left end may be provided on a single ink head. In a similar manner, the white ink head **35**W and the color ink head **35**M that are second from the left may be integrated into one ink head, the white ink head **35**W and the color ink head **35**Y that are second from the right may be integrated into one ink head, and the white ink head **35**W and the color ink head **35**K that are located at the right end may be integrated into one ink head. In this case, one ink head includes an ejection port array of a white ink on the upstream side in the feed direction of the platen **39**, and includes an ejection port array (en ejection port group) of a color ink on the downstream side.

Alternatively, in the example shown in FIG. **2**, at least two of the color ink heads **35**C, **35**M, **35**Y and **35**K may be integrated into one ink head. For example, the color ink heads **35**C and **35**M may be integrated into one ink head, and the color ink heads **35**Y and **35**K may be integrated into one ink head. In this case, one ink head has a structure in which an ejection port group of a certain color ink and an ejection port group of a different color ink are arranged side by side in the main scanning direction. Further, the ejection port group for the white ink including the four ejection port arrays may be mounted on one ink head or on a plurality of ink heads.

The specific configuration of the carriage **34** may also be changed. For example, just the three color ink heads **35**C, **35**M and **35**Y may be used, without using the color ink head **35**K that ejects the black ink. In this case, the black color may be expressed by mixing the three colors of cyan, magenta and yellow. The color ink heads may include an ink head that ejects an ink whose color is not cyan, magenta, yellow or black (an ink head that ejects an ink whose color is gold, silver or the like, for example). The number of the white ink heads **35**W is not limited to four. The number of the nozzles **36** that are provided on each of the ink heads **35** may be changed.

In the printer **30**, the carriage **34** is configured such that the four white ink heads **35**W can be mounted on and removed from the carriage **34**. Therefore, a user can change the number of the white ink heads **35**W mounted on the carriage **34** to a number from one to four. More specifically, even after a model is purchased in which the two white ink heads **35**W are mounted on the carriage **34**, the user can change the model of the printer **30** by additionally mounting two more white ink heads **35**W on the carriage **34**. Although details will be described later, the PC **1** according to the present embodiment can generate print data that causes any of a variety of models having a different number of the white ink heads **35**W to perform printing. The user can also specify only one or some of the plurality of white ink heads **35**W mounted on the carriage **34** to be used for printing.

A printing method that can be performed by the printer **30** in accordance with the print data generated by the PC **1** will be explained. The PC **1** can generate the print data that can cause the printer **30** to eject an amount of ink that is larger than an amount that can be ejected during one scan of the carriage **34**, to each of the dot arrays extending in the main scanning direction. With a particular ink, such as a white ink, there may be cases in which good color development cannot be achieved with only one scan of the carriage **34**. The printer **30** can perform an operation (so-called overlay ejecting) that forms each of the dot arrays through a process of performing scans of the carriage **34** a plurality of times. Therefore, the printer **30** can reproduce good color development by ejecting a large amount of ink onto the print medium. Hereinafter, a printing method in which overlay ejecting of an ink of the same color is performed will be referred to as overprinting.

The PC **1** can also generate the print data that causes the printer **30** to perform printing using a multi-pass method, which is one type of overprinting. The multi-pass method is a method in which a plurality of scans of the carriage **34** is performed with respect to each of the dot arrays and printing is performed using a different one of the nozzles **36** every time a scan is performed with respect to the same dot array. The ink ejection direction and the ink ejection amount may vary for each of the nozzles **36**. Further, movement amounts of the ink heads **35** in the sub-scanning direction may vary. Therefore, if one dot array is completed by one scan (a pass) in the main scanning direction, a stripe may appear (banding may occur) between the dot arrays and thus printing quality may deteriorate. If the amount of ink of each of the dot arrays is different from each other, this may also cause deterioration of printing quality. By performing printing using the multi-pass method (hereinafter also referred to as multi-pass printing), the printer **30** can reduce the influence of various variations derived from the printer **30** itself and to improve printing quality.

In the present embodiment, a first method, a second method and a third method are adopted as specific methods for the printer **30** to perform the above-described overprinting. In the first method, the multi-pass method is used. In the second method, printing of a whole version is repeatedly performed a plurality of times. In the third method, after the carriage **34** is repeatedly moved in the main scanning direction a plurality of times, the platen **39** is moved in the sub-scanning direction. Hereinafter, each of the first to third methods will be explained in detail with reference to FIG. **3** to FIG. **5**.

The first method will be explained. Generally, when print data of the multi-pass method is generated, thinning processing is performed. The thinning processing is processing that controls the ejection amount of ink by thinning out the ink ejection in each of a plurality of scans in accordance with a predetermined algorithm, with respect to the dots that are set as targets of ink ejection. A percentage at which the ink ejection is thinned out in each scan is called a thinning rate. When the thinning processing is performed, a usage rate (%) of the ejection ports in each scan is a value obtained by subtracting the thinning rate (%) from 100%. If the total sum of the usage rates of the ejection ports in the plurality of scans exceeds 100%, an amount of ink can be ejected that is larger than the amount of the ink that can be ejected in a single scan. In other words, with the multi-pass method, it is also possible to increase the amount of ink to be ejected while improving printing quality. Note, however, that if the thinning processing is performed for each scan, a processing load on the PC **1** increases. The PC **1** of the present embodiment can generate the print data of the multi-pass method without increasing the processing load. The specific processing content will be described later.

FIG. **3** shows a case in which printing is performed using the first method with respect to four dot arrays **24**A, **24**B, **24**C and **24**D each including a plurality of dots **23**. First, the printer **30** moves the carriage **34** (refer to FIG. **2**) once in the main scanning direction, and ejects the ink to the dot array **24**A from a particular nozzle X of the plurality of nozzles **36**. Then, the printer **30** moves the print medium to the downstream side (in the upward direction in FIG. **3**) in the feed direction along the sub-scanning direction, with respect to the carriage **34**. The printer **30** then ejects the ink from the nozzle X to the dot array **24**B. The printer **30** performs printing while moving the nozzle X in the main scanning direction once for each of the four dot arrays **24**A to **24**D by repeating the above-described operation. Then, the printer **30** moves the print medium further to the downstream side (in the upward direction in FIG. **3**) in the feed direction and ejects the ink to the dot array **24**A from a nozzle Y that is different from the nozzle X. In a similar manner, by moving the nozzle Y with respect to each of the four dot arrays **24**B to **24**D as well, the printer **30** completes the printing. As described above, in the first method, a different one of the nozzles **36** is moved with respect to each of the four dot arrays **24**A to **24**D every time a scan is performed. As a result, the influence of various variations can be reduced.

The second method will be explained. In the second method, the printing operation is repeated in accordance with one set of print data. A unit operation is defined as an operation that performs printing on an entire printing area while moving one of the nozzles **36** (the nozzle X in FIG. **4**) with respect to each of the dot arrays **24**A to **24**D as shown in FIG. **4**. In a case where the printer **30** is operated using the second method, one set of print data is generated to control the unit operation. When the printer **30** ends the unit operation in accordance with the set of print data, the printer **30** returns the position of the print medium with respect to the carriage **34** to a printing start position and repeats the unit operation. More specifically, overlay ejecting is performed with respect to each of the dot arrays **24**A to **24**D using the same nozzle X. In the second method in which printing of the whole version is repeated, it is possible to inhibit an increase in the amount of print data. Further, after the ink ejected by the single unit operation has dried to a certain extent, the ink is ejected by the next unit operation. Thus, ink bleeding is less likely to occur and it is possible to generate an accurate image.

The third method will be explained. In the third method, the printer **30** performs overlay ejecting of the same ink by moving one of the nozzles **36** in the main scanning direction a plurality of times for one dot array. After that, the printer **30** causes the position of the carriage **34** with respect to the print medium to move in the sub-scanning direction. More specifically, after performing overlay ejecting with respect to one dot array, the printer **30** ejects the ink to the next dot array. In the example shown in FIG. **5**, first, the printer **30** moves the nozzle X in the main scanning direction with respect to the dot array **24**A and ejects the ink. Next, the printer **30** moves the carriage **34** in a reverse direction along the main scanning direction without moving the print medium in the sub-scanning direction, and moves the nozzle X with respect to the dot array **24**A again. After that, the printer **30** moves the print medium in the sub-scanning direction and performs overlay ejecting with respect to the dot array **24**B. Also in the third method, it is possible to inhibit an increase in the amount of print data. Further, the ink to be overlaid is ejected before the previously ejected ink has dried. Therefore, the ink is more likely to bleed and spread in comparison with the second method. As a result, gaps in which no ink is applied can be reduced and the color of the ink can be expressed accurately.

An electrical configuration of the printer **30** will be explained with reference to FIG. **6**. The printer **30** includes a CPU **40** that performs overall control of the printer **30**. A ROM **41**, a RAM **42**, a head drive portion **43**, a motor drive portion **45**, a display control portion **48**, an operation processing portion **50** and a USB interface **52** are each connected to the CPU **40** via a bus **55**.

A control program to control operations of the printer **30** and initial values etc. may be stored in the ROM **41**. The RAM **42** may temporarily store various types of data, such as print data received from the PC **1**. The head drive portion **43** is connected to the ink heads **35** that eject ink. The head drive portion **43** is configured to drive a piezoelectric element that is provided on each of ejection channels of the ink heads **35**. The motor drive portion **45** is configured to drive the main scanning motor **46** and the sub-scanning motor **47**. The main scanning motor **46** may cause the ink heads **35** to move in the main scanning direction via the main scanning mechanism. The sub-scanning motor **47** may cause the platen **39** to move in the sub-scanning direction via the sub-scanning mechanism. The display control portion **48** is configured to control display of a display **49** in accordance with a command from the CPU **40**. The operation processing portion **50** is configured to detect an operation input performed on an operation panel **51**. The USB interface **52** is configured to connect the printer **30** to an external device, such as the PC **1**.

An electrical configuration of the PC **1** will be explained with reference to FIG. **7**. The PC **1** includes a CPU **10** that performs overall control of the PC **1**. A ROM **11**, a RAM **12**, a CD-ROM drive **13**, a hard disk drive (HDD) **14**, a display control portion **16**, an operation processing portion **17** and a USB interface **18** are connected to the CPU **10** via a bus **19**.

Programs, such as a basic input/output system (BIOS) program to be executed by the CPU **10** may be stored in the

ROM 11. The RAM 12 may temporarily store various types of information. A CD-ROM 6, which is a recording medium, may be inserted into the CD-ROM drive 13. Data recorded on the CD-ROM 6 may be read out by the CD-ROM drive 13. The PC 1 may acquire a print data generation program and the like via the CD-ROM 6 or the Internet etc., and store the acquired program and the like in the HDD 14. The HDD 14 is a nonvolatile storage device. The HDD 14 may store the print data generation program and various tables (refer to FIG. 8, for example). The display control portion 16 is configured to control display of a monitor 2. The operation processing portion 17 is connected to a keyboard 3 and a mouse 4 and is configured to detect an operation input. The keyboard 3 and the mouse 4 may be used when the user performs an operation input. The USB interface 18 is configured to connect the PC 1 to an external device, such as the printer 30.

A color mode conversion table 21 will be explained with reference to FIG. 8. The color mode conversion table 21 is a table to convert image data in an sRGB format expressed by 256 gradation levels into image data in a CMYKW format expressed by 256 gradation levels. The image data in the CMYKW format expressed by 256 gradation levels will be hereinafter referred to as gradation data. In the color mode conversion table 21, CMYKW values corresponding to respective sRGB values are associated with each other. The color mode conversion table 21 may be generated using a known method and stored in advance in the HDD 14 of the PC 1. The specific structure of the table may be changed. For example, a table that may be used to convert the sRCGB values into CMYK values and a table that may be used to convert the sROB values to W values may be separately provided. The color mode may be converted through calculation or the like, without using the table.

Main processing that is performed by the PC 1 will be explained with reference to FIG. 9 to FIG. 18. As described above, the print data generation program (a printer driver program) is stored in the HDD) 14 of the PC 1. When a print data generation command is input, the CPU 10 of the PC 1 activates a printer driver in accordance with the print data generation program and performs the main processing shown in FIG. 9.

When the main processing is started, the CPU 10 performs printing condition setting processing (step S1). Printing conditions that are set by the printing condition setting processing will be explained. A number of heads used, a resolution and a maximum density are set in the printing condition setting processing.

The number of heads used is the number of the white ink heads 35W that will be used to eject the ink during a scan in the main scanning direction, among the white ink heads 35W (refer to FIG. 2) mounted on the carriage 34 of the printer 30. In the present embodiment, the carriage 34 is configured such that a maximum of four white ink heads 35W can be mounted on the carriage 34. In the printing condition setting processing, one of the values 4, 2 and 0 may be set as the number of heads used (refer to FIG. 1 to FIG. 13). The number of heads used that can be set may be equal to or less than the number of the white ink heads 35W that can be mounted on the carriage 34. Therefore, in the present embodiment, the values 3 and 1 may also be set as the number of heads used, but an explanation thereof will be omitted.

The resolution is a known printing condition and indicates a dot density. In the present embodiment, one of a resolution of 600 dpi×600 dpi and a resolution of 1200 dpi×1200 dpi may be set. However, another resolution may be set. As the resolution increases, the printing quality can be improved, although the printing time becomes longer.

The maximum density is a parameter indicating a density of the white ink that is to be ejected onto an area for which a maximum amount of the white ink is to be ejected. The user can set the maximum density taking into consideration the color of the print medium, the desired printing quality, the cost of the white ink, the printing time and the like. The PC 1 acquires the gradation data in the CMYKW format expressed by 256 gradation levels (0 to 255) in order to determine an ejection amount of each ink per unit area (dot). The maximum amount of ink is to be ejected to an area with a gradation value of 255. Accordingly, the maximum density is the density of the white ink to be ejected to the area where the value of W in the gradation data is 255. In the present embodiment, it is defined that the density of the maximum amount of the white ink that can be ejected when one of the nozzles 36 of one of the white ink heads 35W is moved once with respect to each of the dot arrays extending in the main scanning direction is 100%. Therefore, in a case where the white ink is ejected using all the four white ink heads 35W mounted on the carriage 34, the density of the white ink that can be ejected by one scan is 400%. Hereinafter, the maximum density of the white ink that can be ejected during one scan of the carriage 34 with respect to each of the dot arrays is referred to as a unit density. The unit density varies in accordance with the number of heads used. In the present embodiment, the unit density (%) can be obtained by multiplying the number of heads used by 100% (unit density=number of heads used×100%). For example, in a case where the unit density is 400% and the maximum density is set to 1000%, the printer 30 needs to move the carriage 34 three times or more with respect to each of the dot arrays. The unit of measurement used for the unit density and the maximum density is not limited to being a percentage, and any unit can be set as appropriate.

The printing condition setting processing will be explained with reference to FIG. 10 to FIG. 13. When the printing condition setting processing is started, the CPU 10 reads from the HDD 14 the number of heads used that has been set in the previous processing, as a candidate value for the number of heads used, and stores the read candidate value in the RAM 12 (step S21). The CPU 10 causes the monitor 2 to display a printing condition input screen (refer to FIG. 11 to FIG. 13) corresponding to the candidate value for the number of heads used (step S22).

A printing condition input screen 61 shown in FIG. 11 is an example in which the candidate value for the number of heads used is 4. In this case, the printing condition input screen 61 is displayed such that the number of heads used, the resolution and the maximum density can all be specified by the user. Further, the printing condition input screen 61 is displayed such that the maximum density can be specified from five densities within a range of 200 to 1000%.

A printing condition input screen 62 shown in FIG. 12 is an example in which the candidate value for the number of heads used is 2. In this case, in the same manner as when the candidate value is 4, the printing condition input screen 62 is displayed such that the number of heads used, the resolution and the maximum density can all be specified. However, the printing condition input screen 62 is displayed such that the maximum density can be specified from only four densities within a range of 200 to 800%. The display of the maximum density of 1000% is grayed out. That is, the CPU 10 changes the range of the maximum density that can be specified, in accordance with the number of heads used. More specifically, the CPU 10 changes the range of the maximum density such that the smaller the specified number of heads used, the lower the upper limit of the range of the maximum density. If printing with a high density is performed in a state in which the number of heads used is small, the number of scans may excessively increase, and the working efficiency may be reduced significantly. For that reason, the CPU **10** changes the range of the maximum density that can be specified, in accordance with the number of heads used. In this manner, it is possible to inhibit a printing condition that may significantly reduce working efficiency from being set by the user.

A printing condition input screen **63** shown in FIG. **13** is an example in which the candidate value for the number of heads used is 0. In this case, the printing condition input screen **63** is displayed such that the number of heads used and the resolution can be specified. The display of the maximum density is grayed out. That is, the CPU **10** prohibits the printing condition relating only to the white ink, among the printing conditions other than the number of heads used, from being displayed and specifiable. Thus, the user can easily know that there is no need to specify the printing condition relating only to the white ink and can perform an operation appropriately.

As shown in FIG. **10**, after the CPU **10** causes the printing condition input screen to be displayed (step S**22**), the CPU **10** acquires, from the HDD **14**, initial values for the resolution and the maximum density that correspond to the number of heads used, as candidate values (step S**23**). The initial values for the resolution and the maximum density are stored in advance in the HDD **14** corresponding to the number of heads used. The initial values may be set for each number of heads used, taking into consideration the printing efficiency, the frequency of those initial values being specified, and the like. In the present embodiment, the initial value of the maximum density is set to 600% when the number of heads used is 4, and is set to 400% when the number of heads used is 2. The initial value of the resolution is 1200 dpi×1200 dpi regardless of the number of heads used. Since the initial values corresponding to the number of heads used are displayed, the user can easily know appropriate printing conditions that are set taking printing efficiency etc. into consideration. In a case where there are three or more values that can be specified as the number of heads used, it is not necessary that all the initial values are different for each number of heads used. The CPU **10** causes the candidate values for the number of heads used, the resolution and the maximum density to be displayed on the printing condition input screen (refer to FIG. **11** to FIG. **13**) (step S**24**). In a case where the user wants to specify a value other than a current candidate value, the user may select a circular button that is displayed next to a desired value by operating the mouse **4** (refer to FIG. **7**) or the like.

The CPU **10** determines whether or not the resolution has been specified (step S**26**). In a case where the resolution has been specified (yes at step S**26**), the CPU **10** stores the specified resolution in the RAM **12** as a candidate value (step S**27**), and causes the stored candidate value for the resolution to be displayed (step S**24**). In a case where the resolution has not been specified (no at step S**26**), the CPU **10** determines whether or not the maximum density has been specified (step S**29**). In a case where the maximum density has been specified (yes at step S**29**), the CPU **10** stores the specified maximum density as a candidate value (step S**30**), and causes the candidate value for the maximum density to be displayed (step S**24**).

In a case where the maximum density has not been specified (no at step S**29**), the CPU **10** determines whether or not a reset command has been input to return the candidate values for the printing conditions to the initial values (step S**32**). In a case where a reset button **65** that is provided on each of the printing condition input screens **61** to **63** (refer to FIG. **11** to FIG. **13**) is operated, the CPU **10** determines that the reset command has been input. In a case where the reset command has been input (yes at step S**32**), the CPU **10** returns the processing to step S**23**. The CPU **10** once again acquires the initial values for the resolution and the maximum density that correspond to the candidate value for the number of heads used that is specified at that point in time (step S**23**), and causes the initial values to be displayed (step S**24**). More specifically, in a case where the reset command is input, the CPU **10** returns the candidate values for the resolution and the maximum density to initial values that correspond to the candidate value for the number of heads used, while maintaining the candidate value for the number of heads used. As a result, the user can easily return to the initial values just the candidate values for the printing conditions that may be changed more frequently than the number of heads used. Thus, there is no need for the user to needlessly re-specify the number of heads used.

In a case where the reset command has not been input (no at step S**32**), the CPU **10** determines whether or not the number of heads used has been specified (step S**33**). In a case where the number of heads used has been specified (yes at step S**33**), the CPU **10** stores the specified number of heads used as a candidate value (step S**34**). The CPU **10** returns the processing to step S**22**, and causes the printing condition input screen that corresponds to the specified number of heads used to be displayed (step S**22**). The CPU **10** acquires initial values that correspond to the number of heads used (step S**23**), and causes the initial values to be displayed (step S**24**). In summary, in a case where the number of heads used is changed, the printing condition input screen is changed to a screen that is suitable for the specified number of heads used. Thus, the user can easily specify the resolution and the maximum density corresponding to the specified number of heads used.

In a case where the number of heads used has not been specified (no at step S**33**), the CPU **10** determines whether or not a cancel command has been input (step S**35**). In a case where a cancel button **66** (refer to FIG. **11** to FIG. **13**) is operated and the cancel command is input (yes at step S**35**), the CPU **10** ends the printing condition setting processing. In a case where the cancel command has not been input (no at step S**35**), the CPU **10** determines whether or not an OK command has been input (step S**36**). In a case where an OK button **67** (refer to FIG. **11** to FIG. **13**) is not operated (no at step S**36**), the CPU **10** returns the processing to the determination processing at step S**26**.

In a case where the OK button **67** is operated and the OK command is input (yes at step S**36**), the CPU **10** identifies the number of the white ink heads **35**W mounted on the carriage **34** of the printer **30** (step S**37**). The number of the white ink heads **35**W mounted on the carriage **34** is hereinafter referred to as the number of mounted heads. Various methods can be used as a method for identifying the number of mounted heads. For example, the CPU **10** may transmit to the printer **30** a command requesting the printer **30** to output the number of mounted heads and receive data indicating the number of mounted heads that is output from the printer **30**. The CPU **10** can thus identify the number of mounted heads. The user may be allowed to input data indicating the number of mounted heads mounted on the printer **30** in advance, and the CPU **10** may store the data in the HDD **14**. Then, by referring to the data stored in the HDD **14**, the CPU **10** may identify the number of mounted heads.

The CPU **10** determines whether or not the number of mounted heads is smaller than the candidate value for the number of heads used (step S**38**). In a case where the number of mounted heads is smaller than the number of heads used (yes at step S38), the printer 30 will not be able to perform printing under the specified printing conditions. Therefore, the CPU 10 outputs an error (step S39), and returns to the determination processing at step S26. As a result, the user can easily know that the specified number of heads used should be changed. Various methods, such as displaying an error screen on the monitor 2 and generating an error sound, can be used as an error output method. In a case where the number of mounted heads is not less than the number of heads used (no at step S38), the CPU 10 sets the candidate values for the number of heads used, the resolution and the maximum density that are stored in the RAM 12, as the printing conditions, and stores the set printing conditions in the HDD 14 (step S40). The CPU 10 returns to the main processing (refer to FIG. 9).

As explained above, with the printing condition setting processing, the user can freely specify the number of heads used and can cause the printer 30 to perform printing. As the number of heads used is increased, the printing can be completed in a shorter time. In a case where overprinting is performed with a reduced number of heads used, the white ink can be ejected after the previously ejected white ink has dried to a certain extent. Thus, if printing with less bleeding is desired, printing quality can be improved. Therefore, by specifying the number of heads used, the user can cause the printer 30 to perform printing in a shorter time using a large number of the white ink heads 35W. Further, the user can also inhibit ink bleeding by specifying a reduced number of the white ink heads 35W. The printing condition setting processing can be commonly used for a plurality of printers with a different number of the white ink heads 35W mounted on the carriage 34. Thus, printer manufacturers and users do not need to prepare separate printer drivers for different types of printers. Even when the number of the white ink heads 35W mounted on the carriage 34 of the printer 30 is changed, the user can easily cause the PC 1 to generate the print data by just changing the specified number of heads used.

As shown in FIG. 9, after the printing condition setting processing (S1) is complete, the CPU 10 acquires image data in the sRGB format expressed by 256 gradation levels (step S2). The CPU 10 converts the acquired image data into gradation data in the CMYKW format expressed by 256 gradation levels using the color mode conversion table 21 (refer to FIG. 8), and stores the gradation data (step S3). The CPU 10 identifies the number of heads used that has been set by the printing condition setting processing at step S1 (step S4). The CPU 10 identifies a unit density U that corresponds to the identified number of heads used (step S5). As described above, in the present embodiment, the unit density U is a value obtained by multiplying the number of heads used by 100. The CPU 10 identifies a maximum density M that has been set (step S6).

The CPU 10 determines a necessary scanning number of times n based on the unit density U and the maximum density M (step S7). The necessary scanning number of times n is a number of limes that the carriage 34 needs to be moved in the main scanning direction with respect to each of the dot arrays in order to eject the white ink of the maximum density M. For example, if the unit density is 400% and the maximum density is 1000%, the necessary scanning number of times n is 3. Specifically, at step S7, the CPU 10 calculates a value K based on the following formula.

$$K=(\text{maximum density } M)/(\text{unit density } U)$$

If the calculated value K is an integer, the CPU 10 determines the value K as the necessary scanning number of times n. If the calculated value K is not an integer, the CPU 10 determines, as the necessary scanning number of times n, a value obtained by adding 1 to a value obtained by rounding down the value K to the nearest integer.

In this manner, the CPU 10 can easily determine an appropriate value as the necessary scanning number of times n, regardless of the value of the maximum density M that has been set. For example, even if the user can freely and directly input the value of the maximum density M, or even if the user can finely change the value of the maximum density M by operating the mouse 4, the CPU 10 can accurately and easily determine the necessary scanning number of times n.

The CPU 10 determines whether or not the necessary scanning number of times n is 2 or more (step S8). In a case where the necessary scanning number of times is 2 or more (yes at step S8), the printer 30 will need to perform overprinting. In this case, the CPU 10 performs gradation value conversion processing (step S9). In the gradation value conversion processing, the gradation value of W is converted in order to generate common data. The common data is data that is used to set an ejection amount of the white ink for each dot. The common data will be used in common for each of a plurality of scans performed in overprinting. In a case where the necessary scanning number of times n is less than 2 (namely, 1) (no at step S8), the CPU 10 advances directly to the processing at step S10.

The gradation value conversion processing will be explained with reference to FIG. 14. The CPU 10 sets, as a target pixel, one of a plurality of pixels that form a printing area in the image data (step S41). The CPU 10 converts the gradation value W of the target pixel (step S42). Specifically, the CPU 10 calculates a value (n×U) by multiplying the necessary scanning number of times n by the unit density U. The CPU 10 then obtain the converted gradation value W by multiplying the gradation value W of the white ink of the target pixel by the ratio of the maximum density M to the obtained value (n×U). The CPU 10 determines whether or not all the pixels have been set as target pixels (step S43). In a case where all the pixels have not been set as the target pixels (no at step S43), the CPU 10 returns to the processing at step S41 and repeats the processing from step S41 to step S43. In a case where the processing is complete for the gradation values W of all the pixels (yes at step S43), the CPU 10 returns to the main processing (refer to FIG. 9).

As shown in FIG. 9, after the processing at step S58 or step S9, the CPU 10 reduces the gradation value of each of the pixels by performing error diffusion processing on the gradation data in the CMYKW format expressed by 256 gradation levels (step S10). By doing this, data in the CMYKW format with reduced gradation levels (hereinafter referred to as low gradation CMYKW data) can be obtained. In a case where the necessary scanning number of times n is two or more, the data of W with reduced gradation levels will be used as common data. The error diffusion processing is known processing that converts the data of 256 gradation levels to data of printing gradation levels. In the present embodiment, the print data is represented by the two values 1 and 0. The value 1 indicates that the ink is to be ejected. The value 2 indicates that the ink is not to be ejected. Therefore, the gradation data is converted to binary data by reducing the gradation values. However, in a case where the printer 30 can process print data of multiple levels (for example, when large/medium/small droplets can be separately ejected), the CPU 10 may convert the gradation data to data of three or more values. The CPU 10 may reduce the gradation values using a method other than the error diffusion method. Next, the CPU 10 performs print data generation processing (step S11). In the print data generation processing, print data to drive the printer 30 is generated in accordance with the low gradation CMYKW data and the set printing conditions. After the print data generation processing, the CPU **10** ends the main processing.

In a case where overprinting is performed by the printer **30**, in the related art, the print data to control the operations of the printer **30** is generated for each scan of the carriage **34**. Therefore, as compared to a case in which overprinting is not performed, the processing load on the PC **1** is increased and the data volume of the print data is also increased. Particularly, in a case where the PC **1** generates the print data for the multi-pass method in this manner, the PC **1** performs the thinning processing for each scan. The thinning processing is processing that controls the ejection amount of ink by thinning out the ink ejection in each of a plurality of scans in accordance with a predetermined algorithm, with respect to the dots that are set as targets of ink ejection. In a case where the thinning processing is performed for each scan, the processing load on the PC **1** is increased. In a case where a mask pattern (a thinning pattern), which is used when the thinning processing is performed, is generated for each scan, the processing load on the PC **1** is further increased. In contrast, in the present embodiment, the CPU **10** can easily generate common data of W that sets the ejection amount of the white ink for each dot. Since the generated common data can be used in common for each of scans when overprinting is performed, the data volume can be made small. The CPU **10** does not need to generate data for each scan and also does not need to perform the thinning processing for each scan. As a result, the CPU **10** can quickly generate the print data with a reduced processing load.

The print data generation processing will be explained in more detail with reference to FIG. **15** to FIG. **18**. As shown in FIG. **15**, first, the CPU **10** determines whether or not the necessary scanning number of times n is 2 or more (step S**51**). In a case where the necessary scanning number of times is 1 (no at step S**51**), there is no need to change the density of the white ink to be higher than the unit density U. Therefore, the CPU **10** generates print data using the same method as in the related art (step S**52** to step S**54**). Specifically, in a case where the number of heads used is a value other than 0 and printing with the white ink will be performed (no at step S**52**), the CPU **10** generates CMYKW print data from the low gradation CMYKW data (step S**53**). In a case where the number of heads used is 0 and printing with the white ink will not be performed (yes at step S**52**), the CPU **10** generates CMYK print data from the low gradation CMYKW data except the data of W (step S**54**). After the processing at step S**53** or step S**54**, the CPU **10** ends the print data generation processing. In a case where settings for the multi-pass printing to be performed have been made by the user in advance, the CPU **10** generates, in the processing at step S**53** or step S**54**, the print data to cause the printer **30** to operate using the multi-pass method. In this case, the print data generated at step S**53** is not intended to change the density of the white ink to be higher than the unit density U. Therefore, when the printer **30** operates based on the print data generated at step S**53**, the white ink, whose density in total is the same as that of the white ink that can be ejected during one scan of the carriage **34**, is ejected during a plurality of scans using the multi-pass method.

In a case where the necessary scanning number of times n is two or more and overprinting with the white ink will be performed (yes at step S**51**), the CPU **10** performs white head setting processing (step S**56**). In the white head setting processing, the white ink head(s) **35**W that will be caused to eject the ink in each scan, namely, the white ink head(s) **35**W to be used, is set from among the white ink heads **35**W mounted on the carriage **34**.

As shown in FIG. **16**, the CPU **10** determines whether or not the number of mounted heads (refer to step S**37** in FIG. **10**) is larger than the number of heads used (step S**71**). In a case where the number of mounted heads is the same as the number of heads used (no at step S**71**), all the white ink heads **35**W mounted on the carriage **34** will be used in all the scans. Therefore, the CPU **10** returns directly to the print data generation processing (refer to FIG. **15**).

In a case where the number of mounted heads is larger than the number of heads used (yes at step S**71**), the CPU **10** determines whether or not the head(s) to be used has been specified (step S**72**). In a case where the user wants to use particular one or some of the white ink heads **35**W, the user may input, to the PC **1** in advance, information that specifies the white ink head or heads **35**W to be used. For example, if some of the while ink heads **35**W are not functioning, the user can specify one or some of the white ink heads **35**W that are functioning, as the head or heads to be used. In a case where the head(s) to be used has been specified (yes at step S**72**), the CPU **10** identifies the specified white ink head(s) **35**W as the white ink head(s) **35**W to be used in all the scans (step S**73**). The CPU **10** returns to the print data generation processing.

In a case where the head(s) to be used has not been specified (no at step S**72**), the CPU **10** randomly selects, from among the white ink heads **35**W mounted on the carriage **34**, the same number of the white ink heads **35**W as the number of heads used for each of the scans that will be performed. The CPU **10** sets the randomly selected white ink heads **35**W as the heads to be used (step S**74**). The CPU **10** returns to the print data generation processing. Due to the processing at step S**74**, the PC **1** will generate the print data to perform printing while the white ink heads **35**W that eject the white ink are changed for each scan. Therefore, the PC **1** can inhibit the ink from drying on the nozzles **36** as a result of a particular one of the white ink heads **35**W not being used for a long time, and it is thus possible to improve printing quality. The possibility of ink clogging may also be reduced.

As shown in FIG. **15**, after the white head setting processing (step S**56**), the CPU **10** accepts a printing method selection command (step S**57**). More specifically, the CPU **10** causes the monitor **2** to display the following three printing methods for overprinting, in a selectable manner. The three methods are a first method (the multi-pass method), a second method (a method that prioritizes prevention of bleeding), and a third method (a method that prioritizes white color development). The user may operate the mouse **4** etc. and input a command to select one of the printing methods to the PC **1**. In a case where the first method is selected (yes at step S**59**), the CPU **10** performs first generation processing (step S**60**), and ends the print data generation processing. Although details will be described later, in the first generation processing, print data to cause the printer **30** to perform printing using the first method is generated from the low gradation CMYKW data.

In a case where the selected printing method is not the first method (no at step S**59**) but the second method (yes at step S**62**), the CPU **10** performs second generation processing (step S**63**) and ends the print data generation processing. In the second generation processing. CMYKW print data to cause the printer **30** to repeatedly perform a whole version of white color printing a plurality of times is generated from the low gradation CMYKW data (refer to FIG. **4**). As described above, the data of W among the low gradation CMYKW data is the common data. In the second method, if the necessary scanning number of times n is four, for example, after the printer **30** repeats three times a printing operation of a version of white color only, the printer **30** performs simultaneous printing of a white color version and a color version in the fourth scan and ends the printing. That is, in the final unit operation, the printer **30** ejects the color inks onto the over-printed white ink using the color ink heads **35**CL while performing n-th overlay ejecting of the white ink using the white ink heads **35**W. It is also possible that the printer **30** repeats n times a unit operation that performs printing of the white ink only using the white ink heads **35**W, and thereafter performs a unit operation once using the color ink heads **35**CL only. With the second generation processing, the PC **1** can generate the print data that may suppress ink bleeding and develop a stable color.

In a case where the selected printing method is the third method (no at step S**62**), the CPU **10** generates CMYKW print data from the low gradation CMYKW data in third generation processing (step S**64**), and ends the print data generation processing. The data of W among the low gradation CMYKW data is the common data. With the print data generated by the third generation processing, after the printer **30** has completed the ejection of the white ink with respect to one dot array by performing scans n times, then, with respect to the next dot array, the printer **30** causes the white ink to be ejected by performing scans n times in the same manner (refer to FIG. **5**). The color inks are ejected in any one of the scans performed n times when the color ink heads **35**CL are disposed above the dot array for which the white ink printing has already been completed, along with the movement of the platen **39** to the downstream side in the feed direction. With the print data generated by the third generation processing, it is possible to inhibit the generation of gaps by blurring the ink moderately and it is possible to obtain good color development.

The first generation processing will be explained with reference to FIG. **17**. Characteristics of the print data for the multi-pass method that is generated by the first generation processing will be explained. As described above, in the multi-pass printing, the printing is performed such that a different one of the nozzles **36** is used every time a scan is performed with respect to each of the dot alleys. Therefore, the influence of various variations can be reduced and printing quality can be improved. In the multi-pass printing, as the number of times that the different nozzles **36** are moved with respect to the same dot array is increased (namely, as the number of the nozzles **36** that form one dot array is increased), the influence of variations can be notably reduced. Hereinafter, the number of times that the different nozzles **36** are moved with respect to the same dot array is referred to as the number of passes. The first generation processing is intended to improve printing quality, using the above-described characteristics. Generally, the number of passes that can be set in multi-pass printing is limited in accordance with the number of the nozzles **36** provided on each of the ink heads **35**. This is because, unless the number of passes is a divisor (except 1) of the number of the nozzles **36**, control of the multi-pass printing becomes complicated. In the present embodiment, the number of the nozzles **36** provided on each of the ink heads **35** is 128. Therefore, the number of passes that can be set is limited to the divisors of 128, except 1 (namely, 2, 4, 8, 16, 32, 64 and 128). Therefore, in a case where the necessary scanning number of times n matches none of the number of passes that can be set in multi-pass printing, it is necessary to cause the printer **30** to perform overprinting using a method in which multi-pass printing is performed a plurality of times, or a method in which multi-pass printing and normal printing are both performed. In this case, in the first generation processing, optimal print data is generated by taking account of both the printing quality and the printing efficiency.

As shown in FIG. **17**, when the first generation processing is started, the CPU **10** sets a printing unit number R to 1 (step S**1**). In the explanation below, in a case where printing is performed using a single method without performing multi-pass printing, one scan that is performed using the single method is taken as one unit of printing. The single method is a method in which printing is performed by moving one of the nozzles **36** provided on each of the ink heads **35** once with respect to one dot array. Further, a plurality of scans that are performed using the multi-pass method by the set number of passes are collectively taken as one unit of printing. For example, in the example shown in FIG. **18**, four scans that are performed using the multi-pass method (i.e., the fourth scan to the seventh scan) are collectively taken as one unit of printing (R=1). Two scans that are performed using the multi-pass method (i.e., the second scan and the third scan) are collectively taken as one unit of printing (R=2). The first scan that is performed using the single method is taken as one unit of printing (R=3).

The CPU **10** sets a remaining processing number S to the necessary scanning number of times n (step S**82**). The remaining processing number S is the number of scans for which corresponding print data has not yet been generated (namely, scans to which print data is to be assigned), among the plurality of scans that are to be performed the necessary scanning number of times n.

The CPU **10** identifies a number of passes P which is the largest among the numbers of passes that can be set and which is not more than the remaining processing number S (step S**83**). As described above, in the present embodiment, the number of passes that can be set is limited to the divisors of 128, except 1, and one of the seven numbers 2, 4, 8, 16, 32, 64 and 128 can be set. As in the example shown in FIG. **18**, in a case where the necessary scanning number of times n is 7, the value of the remaining processing number S that has been set at step S**82** is 7. In this case, the value 4, which is the largest value among the divisors of 128 and which is equal to or less than the remaining processing number S, is identified as the first number of passes P.

The CPU **10** determines whether or not the set printing unit number R is 1 (step S**84**). In a case where the printing unit number R is 1 (yes at step S**84**), the CPU **10** sets, as a final printing unit, P times of continuous scans including the final (n-th) scan, among the scans that are to be performed the necessary scanning number of times n (step S**85**). The final printing unit is a unit of printing to be performed at the end of the printing operation. The CPU **10** generates W print data for the final printing unit to cause the printer **30** to eject white ink, whose density will be made higher than the unit density U, using the multi-pass method (step S**86**). In the processing at step S**86**, although the common data of W is used in common for all of the P times of scans included in the final printing unit, the W print data is generated to operate the printer **30** such that the nozzle **36** that ejects the white ink to each dot array is different for each scan. Thus, with the use of the common data, the CPU **10** can easily generate the W print data with a reduced data volume, without performing the thinning processing. From the data of CMYK among the low gradation CMYKW data, the CPU **10** generates CMYK print data for the final printing unit to cause the printer **30** to eject the color inks, whose density will be a normal density that is equal to or lower than the unit density U, using the multi-pass method (step S**87**). In the processing at step S**87**, the thinning processing is performed for each scan. The thinning processing is known processing and thus an explanation thereof is omitted.

The CPU **10** subtracts, from the remaining processing number S, the number of passes P for which the print data assignment is complete (step S**92**). The CPU **10** determines whether or not the remaining processing number S is 0 (step S**93**). In a case where the remaining processing number S is not 0 (no at step S**93**), the CPU **10** adds 1 to the printing unit number R (step S**94**) and returns to the processing at step S**83**. In the example shown in FIG. **18**, the remaining processing number S becomes 3 in the processing at step S**92** that is performed in the first cycle. Thus, in the processing at step S**83** that is performed in the second cycle, 2 is identified as the number of passes P which is the largest and which is equal to or lower than the remaining processing number S.

In a case where the printing unit number R is not 1 (no at step S**84**), the CPU **10** determines whether or not the number of passes P has been identified by the processing at step S**83** performed immediately before step S**84** (step S**89**). In a case where the number of passes P has been identified (yes at step S**89**), the CPU **10** sets, as the printing unit number R, the continuous P times of scans to be performed immediately before the unit of printing whose printing unit number is (R . . . 1) (namely, the unit of printing that has been processed last time) (step S**90**). In the example shown in FIG. **18**, as the unit of printing whose printing unit number R is 2, the second scan and the third scan are set that are to be performed immediately before the unit of printing (the final printing unit) whose printing unit number R is 1 and which has been processed last time. The CPU **10** generates W print data for the set unit of printing to cause the printer **30** to eject the white ink, whose density will be made higher, using the multi-pass method (step S**91**). As a result, a plurality of sets of multi-pass printing will be performed by the printer **30**. The CPU **10** advances to the processing at step S**92**.

In a case where the number of passes P has not been identified by the processing at step S**83**, it is not possible to perform the multi-pass printing in the remaining scan(s). In a case where the printing can be completed using the multi-pass method only, it is necessary that the necessary scanning number of times n matches one of the numbers of passes that can be set, or matches the sum of at least two of the numbers of passes that can be set. In a case where the number of passes P has not been identified (no at step S**89**), the CPU **10** generates W print data for the remaining scan(s) (the first scan in the example shown in FIG. **18**) to cause the printer **30** to perform printing using the single method (step S**96**). The CPU **10** ends the first generation processing. In this manner, the PC **1** can easily generate the print data that allows good printing quality to be obtained, regardless of the necessary scanning number of times n. In the example shown in FIG. **18**, the remaining processing number S becomes 1 in the processing at step S**92** that is performed in the second cycle. Therefore, the number of passes P is not identified by the processing at step S**83** that is performed in the third cycle, and in the processing at step S**96**, W print data for the unit of printing whose printing unit number R is 3 (namely, the first scan) is generated that causes the printer **30** to perform printing using the single method. When the remaining processing number S becomes 0 as a result of subtracting the number of passes P for which the print data assignment is complete from the remaining processing number S (yes at step S**93**), the processing is complete for all the scans to be performed n times. Therefore, the CPU **10** ends the first generation processing.

There are various methods for combining the single method and the multi-pass method at step S**96**. For example, print data that causes the nozzle **36** of the white ink to move once with respect to all the dot arrays may be generated before the multi-pass printing is performed. The single method and the multi-pass method may be combined by repeating the first scan in the main scanning direction that is performed for the first time in the multi-pass method, without moving the print medium in the sub-scanning direction. In the example shown in FIG. **18**, for example, the CPU **10** may generate print data that causes the printer **30** to operate in the following manner. In the first scan, the printer **30** uses one of the nozzles **36** for the white ink to eject the white ink once for all the dot arrays using the single method. Next, the printer **30** performs multi-pass printing in which the number of passes is 2, and performs overlay ejecting with just the white ink twice. Further, the printer **30** performs multi-pass printing in which the number of passes is 4, and performs overlay ejecting of the white ink and ejecting of the thinned-out color inks at the same time. The white ink heads **35**W are located on the upstream side with respect to the color ink heads **35**CL in the feed direction of the platen **39**. Therefore, the white ink heads **35**W enter the printing area ahead of the color ink heads **35**CL. As a result, the color inks are ejected onto the printing area on which the printing with the white ink has been completed.

With the print data that is generated by the first generation processing of the present embodiment, the printer **30** ejects both the white ink (the high density ink) and the color inks (the normal density ink) during a plurality of scans (the final printing unit) including the final scan, among the plurality of scans that are performed n times. As a result, at least the topmost surface of the white printing surface is formed by the multi-pass printing. Accordingly, the printing quality of the white ink can be improved. The printer **30** also ejects the color inks in the multi-pass printing in the final printing unit. Accordingly, the printing quality of the color inks can also be improved. Further, the printer **30** performs the multi-pass printing in the process of overprinting to increase the density of the white ink. Therefore, there is no need to increase the number of scans of the carriage **34** in the main scanning direction, and the printing efficiency can also be maintained high. Even in a case where the minimum value (2 in the present embodiment) of the number of passes that can be set does not match the necessary scanning number of times n for overprinting, the PC **1** can generate the print data that causes the printer **30** to perform both the white ink printing and the color ink printing efficiently, with good printing quality.

With the print data generated by the first generation processing of the present embodiment, in a case where the printer **30** performs a plurality of sets of multi-pass printing, the number of passes of multi-pass printing of the final set (the final printing unit) is the largest among the numbers of passes of the plurality of sets of multi-pass printing. As a result, the topmost surface of the white ink and the color ink are formed by multi-pass printing with an increased number of passes. Thus, the PC **1** can generate the print data that causes the printer **30** to efficiently perform printing with higher quality. In addition, with the print data generated by the first generation processing of the present embodiment, the printer **30** performs an increased number of multi-pass printing with an increased number of passes. Therefore, the PC **1** can improve the printing quality as compared to a case in which an increased number of sets of multi-pass printing with a reduced number of passes is performed.

Next, print processing that is performed by the printer **30** will be explained below with reference to FIG. **19**. As described above, the various programs to control the operations of the printer **30** are stored in the ROM **41** of the printer **30**. When a printing execution command is input from the operation panel **51**, for example, the CPU **40** of the printer **30** activates a program for the print processing, and performs the print processing shown in FIG. **19**. The CPU **40** may start the print processing when the printer **30** receives print data from an external device, such as PC **1**, via the USB interface **52**.

The CPU **40** acquires the print data of an object to be printed (step S**101**). Note that the print data that has been received from an external device, such as PC **1**, may be stored in the RAM **42**. The CPU **40** identifies the number of scans N based on the print data, and determines whether or not the number of scans N is less than 2 (step S**102**). The number of scans N is a number of times that the carriage **34** will be moved in the main direction to complete the printing. In a case where the number of scans N is less than 2, namely, in a case where the number of scans is 1 (yes at step S**102**), the CPU **40** performs printing by causing at least one of the white ink and the color ink to be ejected onto the print medium while the carriage **34** is moved once in the main scanning direction (step S**103**).

More specifically, the CPU **40** generates, in accordance with the print data, drive signals to drive the main scanning motor **46**, the sub-scanning motor **47** and the piezoelectric elements of the ink heads **35**, respectively, and outputs the generated drive signals to the motor drive portion **45** and the head drive portion **43**. Thus, the CPU **40** may control the movement of the carriage **34**, the movement of the print medium that is placed on the platen **39**, and the ejection of the ink from the ejection ports of the nozzles **36**. At step S**103**, during one scan, only the white ink, only the color inks, or both of the white ink and the color inks are ejected. After ejecting the ink during one scan. The CPU **40** ends the print processing shown in FIG. **19**.

In a case where the number of scans N is not less than 2 (no at step S**102**), the CPU **40** sets a variable c stored in the RAM **42** to an initial value of 1 (step S**105**). The variable c is a variable to sequentially process the print data and indicates the number of the scan that is the current processing target, among the plurality of scans. The CPU **40** identifies data that corresponds to the scan (the first scan in the first cycle of the processing) that is indicated by the variable c, among the print data that has been acquired at step S**101**, and determines whether or not the identified data is data for ejecting only the white ink (step S**106**).

More specifically, in a case where the first generation processing (step S**60**) has been performed in the print data generation processing (refer to FIG. **15**), the print data has been generated that causes the printer **30** to eject only the white ink using the single method or the multi-pass method (yes at step S**106**). In a case where the second generation processing (step S**63**) has been performed, the print data has been generated that causes the printer **30** to print the version of the white ink only during a scan in the early phase (yes at step S**106**). In a case where the third generation processing (S**64**) has been performed, the print data has been generated that causes the printer **30** to eject only the white ink a plurality of times with respect to one dot array during a scan in the early phase (yes at step S**106**). In any one of these cases, the CPU **40** performs printing by ejecting the white ink onto the print medium while the carriage **34** is moved once in the main scanning direction (step S**108**). Specifically, the CPU **40** generates, in accordance with the data that corresponds to the c-th scan, drive signals to drive the main scanning motor **46**, the sub-scanning motor **47** and the piezoelectric elements of the ink heads **35**, respectively, and outputs the generated drive signals to the motor drive portion **45** and the head drive portion **43**. Thus, the CPU **40** may control the movement of the carriage **34**, the movement of the print medium that is placed on the platen **39**, and the ejection of the ink from the ejection ports of the nozzles **36**. At step S**108**, during one scan, only the white ink is ejected.

After the white ink is ejected during the scan, the CPU **40** adds 1 to the variable c stored in the RAM **42** (step S**11**), thereby sets the data that corresponds to the next scan as the processing target. The CPU **40** determines whether or not that the variable c exceeds the number of scans N (step S**112**). In a case where the variable c does not exceed the number of scans N (no at step S**112**), the printing has not been completed. Therefore, the CPU **40** returns to the processing at step S**106**.

In a case where the data that corresponds to the scan that is indicated by the variable c is not the data for causing only the white ink to be ejected (no at step S**106**), the CPU **40** determines whether or not the data is data for causing only the color inks to be ejected (step S**107**). In a case where the processing target data is data for causing the color inks as well as the white ink to be ejected (no at step S**107**), the CPU **40** performs printing by ejecting the white ink and the color inks onto the print medium while the carriage **34** is moved once in the main scanning direction (step S**109**). The processing at step S**109** is similar to the processing at step S**108**, except that the both the white ink and the color inks are ejected during one scan at step S**109**.

Note that the color inks are ejected by the color ink heads **35**L that are disposed on the downstream side in the feed direction of the print medium onto the white ink that has been ejected onto the print medium in advance by the white ink heads **35**W that are disposed on the upstream side.

After the white ink and the color inks are ejected during the scan, the CPU **40** adds 1 to the variable c that is stored in the RAM **42** (step S**111**), thereby sets the data that corresponds to the next scan as the processing target. In a case where the variable c does not exceed the number of scans N (no at step S**112**), the CPU **40** returns to the processing at step S**106**. In a case where the data that corresponds to the scan that is indicated by the variable c is data for causing only the color inks to be ejected (yes at step S**107**), the CPU **40** performs printing by ejecting only the color inks onto the print medium while the carriage **34** is moved once in the main scanning direction (step S**110**). The processing at step S**110** is similar to the processing at step S**108**, except that only the color inks are ejected during one scan at step S**110**. Note that, as in step S**109**, the color inks are ejected by the color ink heads **35**L onto the white ink that has been ejected onto the print medium in advance by the white ink heads **35**W. When the variable c exceeds the number of scans N (yes at step S**112**), as a result of repeating the processing of steps S**106** to S**112**, the CPU **40** determines that printing is complete and ends the print processing shown in FIG. **19**.

In the printer **30**, the ejection port group (the white ink heads **35**W in the present embodiment) that can eject the white ink is located on the upstream side of the ejection port groups (the color ink heads **35**CL in the present embodiment) that can eject the color inks. Therefore, the print medium that is fed by the driving of the sub-scanning motor **47** reaches a position that corresponds to the ejection port group for the white ink before the print medium reaches a point that corresponds to the ejection port groups for the color inks. For that reason, the printer **30** can efficiently perform the processing of ejecting the color inks onto the dot array onto which the white ink has been ejected a plurality of times.

Various modifications can be made to the above-described embodiment. The above-described embodiment is an example in which the processing for setting the printing conditions and the processing for generating the print data are performed by the PC **1** that is an external device to the printer **30**. However, an apparatus that can operate as an apparatus for generating the print data is not limited to the PC **1**. For example, the printer **30** (more specifically, the CPU **40**) may generate the print data by performing the main processing shown in FIG. **9**. In such a case, the CPU **40** of the printer **30** may first generate the print data through the main processing shown in FIG. **9** and then the CPU **40** may perform the print processing shown in FIG. **19** when the print execution command is input.

The processing shown in FIG. **9** to FIG. **18** may be performed by a plurality of apparatuses included in the printing system **100**. For example, in the above-described embodiment, in a case where the number of mounted heads is smaller than the candidate value for the number of heads used, the PC **1** outputs an error (refer to step S**38** and step S**39** in FIG. **10**). However, the PC **1** need not necessarily output an error. More specifically, the PC **1** may generate the print data without performing the processing at step S**38** and step S**39** shown in FIG. **10** and may transmit the generated print data to the printer **30**. The CPU **40** of the printer **30** may read the number of heads used from the received print data, and in a case where the number of mounted heads is smaller than the number of heads used, the printer **30** may output an error. The printer **30** may store the number of mounted heads in advance. The printer **30** may identify the number of mounted heads using a switch, a sensor or the like that is configured to detect the mounting of the white ink heads **35**W. It is also possible that the PC **1** performs the printing condition setting processing (step S**1**) of the main processing (refer to FIG. **9**) and the printer **30** performs the processing from step S**2** to step S**11**. In this case, the PC **1** may transmit the set printing conditions to the printer **30**. The printing system **100** may include two personal computers **1**. In this case, the first PC **1** may perform the printing condition setting processing (step S**1**) and the second PC **1** may perform the processing from step S**2** to step S**11**, for example. As described above, each of the processing steps explained in the above-described embodiment may be performed by any one of the apparatuses included in the printing system **100**, or may be divided and performed by the apparatuses.

It is needless to mention that the format and the gradation levels etc. of the various types of data, such as image data, can be changed. For example, the format of the image data that is acquired by the PC **1** at step S**2** shown in FIG. **9** is not limited to the data in the sRGB format, and the gradation levels is also not limited to 256 levels. In the same manner, the data format and the gradation levels of the gradation data need not necessarily be limited to the CMYKW format and 256 levels. Another color (for example, orange) other than cyan, magenta, yellow, black and white may be used. It is also possible for the print data to have multiple values (three or more gradation levels). The PC **1** may directly acquire the gradation data in the CMYKW format from another device, instead of acquiring the image data in the sRGB format.

In the above-described embodiment, the exemplified printing system **100** can perform overprinting of the white ink. However, the present disclosure can be applied without being limited to the case in which overprinting of the white ink is performed. For example, the present disclosure can also be applied to a case in which an ink for which overprinting is desirable to obtain good color development as in the case of the white ink. For example, the present disclosure can be applied to a case in which the background is completely painted in silver color without gaps.

A plurality of the white ink heads **35**W that eject the same white ink can be mounted on the printer **30** of the above-described embodiment. The present disclosure can also be applied to a case in which a plurality of the ink heads **35** that eject different inks of similar colors are mountable on the printer **30**. For example, a plurality of the white ink heads **35**W for which ink color tones are slightly different from each other may be mounted on the printer **30**. In this case, the user can specify a desired one or more of the white ink heads **35**W in accordance with the color tone of the white ink. Further, the white ink may be ejected simultaneously from a plurality of the white ink heads **35**W. The number of the nozzles **36** provided on each of the ink heads **35** is not limited to 128.

In the above-described embodiment, there are three conditions specified for the printing conditions, namely, the number of heads used, the resolution, and the maximum density. However, the printing conditions that can be specified can be changed. For example, the resolution may not be specified. Another condition may be specified as a printing condition. More specifically, the PC **1** may allow the user to specify a condition (for example, brightness of an image) other than the above-described three printing conditions.

In the above-described embodiment, the maximum density may be specified by the user as shown by the processing at step S**29** in FIG. **10**, for example. Therefore, the user can cause white color printing to be performed at a desired density. However, the maximum density need not necessarily be specified by the user. For example, the PC **1** may store in advance the maximum density that is suitable for the color, the material and the like of the print medium, and may automatically set the maximum density that is suitable for the print medium on which printing is to be performed. When image data is generated, data of the maximum density may be added to the image data. The maximum density may be a fixed value and only the unit density may be changed. In a case where the maximum density is specified by the user, the method for accepting an input to specify the maximum density can be changed as appropriate. For example, the PC **1** may accept a value for the maximum density that is input directly by the user using the keyboard **3** and the like. The PC **1** may set the maximum density in accordance with information indicating the color and the like of the print medium input by the user. This also applies to the input of the resolution.

The number of heads used need not necessarily be specified directly by the user. For example, the PC **1** may set, as the number of heads used, the number of mounted heads corresponding to a model name that is specified by the user from among model names of the plurality of printers **30** having a different number of mounted heads.

In a case where the candidate value of the number of heads used is **0**, the PC **1** of the above-described embodiment grays out the display of the maximum density on the printing condition input screen **63** (refer to FIG. **13**). In this manner, the PC **1** inhibits the maximum density from being displayed in a state in which it can be specified (refer to step S**22** in FIG. **10**). When the range of the maximum density that can be specified is changed, the graying-out technique is also used (refer to FIG. **12**). However, the method for limiting the display state in which the maximum density can be specified is not limited to the graying-out technique. For example, it is possible for the PC **1** not to display the candidates of the maximum density. It may be desirable for a user's convenience that the printing condition input screens **61** to **63** are changed in accordance with the candidate value for the number of heads used, as in the above-described embodiment. However, a common printing condition input screen may be used regardless of the number of heads used.

In the above-described embodiment, the minimum number of scans that are required to perform printing at the maximum density M is determined as the necessary scanning number of times n at step **S7** in FIG. **9**. Thus, the PC **1** can inhibit the printing time from being increased more than is necessary. However, the number scans that is equal to or more than the minimum number of scans may be determined as the necessary scanning number of times n.

In the above-described embodiment, the white head to be used is randomly selected for each scan at step **S74** in FIG. **16**. As a result, there is a less possibility that the nozzles **36** of a particular one of the white ink heads **35**W will dry up. However, the method for selecting the white head to be used may be changed. For example, the white head to be used may be changed every time a predetermined number of scans (for example, five scans) are performed, instead of being changed every time one scan is performed. The PC **1** may change the white head to be used every time the PC **1** generates print data. The PC **1** may set the white head to be used in accordance with a predetermined order, instead of randomly selecting the white head to be used.

The PC **1** of the above-described embodiment sets the number of passes of multi-pass printing in the final set (the final printing unit), among a plurality of sets of multi-pass printing, to be largest, in the first generation processing shown in FIG. **17**. As a result, the topmost surface of the white printing surface is formed by multi-pass printing with a large number of passes. Thus, the printing quality can further be improved. Further, the PC **1** generates the print data that causes the printer **30** to perform multi-pass printing as many times as possible such that the number of passes is increased as much as possible. As a result, it is possible to further improve the printing quality. However, if multi-pass printing is performed only in the final printing unit, the printing quality (particularly, the color printing quality) can be improved as compared to a case in which printing with the single method is performed in the last scan. Therefore, for example, the number of passes of each of a plurality of sets of multi-pass printing may be the same number. Specific processing contents of the first generation processing shown in FIG. **17** may be changed. For example, after performing the processing (refer to step **S85** to step **S87**) that generates the print data that causes multi-pass printing to be performed in the final printing unit, the PC **1** may perform the processing (step **S96**) that generates the print data that causes printing with the single method to be performed in all the remaining scans. In this case, the processing from step **S89** to step **S94** may be omitted. Even in a case where multi-pass printing is not performed in the final printing unit, multi-pass printing may be included in a printing operation. In this case, the printing quality can be improved as compared to a case in which multi-pass printing is not included.

The printer **30** of the above-described embodiment is configured such that the white ink heads **35**W and the color ink heads **35**C, **35**M, **35**Y and **35**K can be mounted on the single carriage **34**. Therefore, the printer **30** can perform simultaneous printing of white and color. In the first generation processing (refer to FIG. **17**), the PC **1** generates the print data that causes the printer **30** to perform multi-pass printing in the final printing unit. With this print data, it is possible to cause the printer **30** to perform simultaneous printing of white and color with high quality, without increasing the number of scans. However, the present disclosure can also be applied to a case in which a printer that does not perform simultaneous printing of white and color is used. More specifically, with the processing that generates the common data (refer to step **S9** and step **S10** in FIG. **9**), the PC **1** can easily and appropriately generate the print data to perform overprinting, regardless of whether or not the printer **30** is caused to perform simultaneous printing. In a similar manner, with the printing condition setting processing (refer to FIG. **10**), the user can change the number of heads used, taking printing quality and printing time into consideration, regardless of whether or not the printer **30** is caused to perform simultaneous printing. The processing that generates the common data and the printing condition setting processing can also be applied to the generation of print data that causes a printer that prints with only one color (for example, white) to perform printing. It is also possible that, of the processing explained in the above-described embodiment, only the processing that generates the common data is applied, and the processing that generates the print data from the common data is simplified (for example, the processing at step **S63** in FIG. **15** only is adopted).

In the above-described embodiment, single CPU may perform all of the processing. Nevertheless, the disclosure may not be limited to the specific embodiment thereof, and a plurality of CPUs, a special application specific integrated circuit ("ASIC"), or a combination of a CPU and an ASIC may be used to perform the processing.

The apparatus and methods described above with reference to the various embodiments are merely examples. It goes without saying that they are not confined to the depicted embodiments. While various features have been described in conjunction with the examples outlined above, various alternatives, modifications, variations, and/or improvements of those features and/or examples may be possible. Accordingly, the examples, as set forth above, are intended to be illustrative. Various changes may be made without departing from the broad spirit and scope of the underlying principles.

What is claimed is:

1. An apparatus comprising:

a control portion; and

a non-transitory memory configured to store computer-readable instructions that, when executed by the control portion, cause the apparatus to perform the steps of:

determining a scanning number of times being a number of times that a printer carriage mounting a plurality of ink heads thereon is to be moved in a main scanning direction to form a single line image formed by a single dot array extending in the main scanning direction and having a width, in a sub scanning direction orthogonal to the main scanning direction, corresponding to a size of a nozzle formed in the ink head and to increase a maximum density of a first ink in the single line image to be higher than a unit density by ejecting the first ink a plurality of times to the single dot array, the printer carriage being provided in a printer, the plurality of ink heads having at least one first ink head configured to eject the first ink and at least one second ink head configured to eject a second ink, the one first ink head and the one second ink head being aligned along the sub scanning direction, the unit density being a density of a maximum amount of ink that can be ejected by moving the carriage once with respect to a single dot array; and

generating, in a case where the scanning number of times is larger than a minimum value of a number of passes that can be set as a number of times of scans of a set of multi-pass scans, print data to cause ejection of the first ink and ejection of a second ink to be performed by the multi-pass scans in a final printing unit, among a plurality of scans to be performed a plurality of times equal to the scanning number of times, the set of multi-pass scans being a set of a plurality of scans in which, every time a scan is performed, an ink is ejected to the single dot array from a nozzle different from a nozzle used in a preceding scan, among a plurality of nozzles provided on each of the plurality of ink heads, the final printing unit being continuous scans corresponding to the number of passes including a last scan, among the scans to be performed the scanning number of times, and the second ink being an ink whose density is equal to or less than the unit density.

2. The apparatus according to claim **1**, wherein

in a case where a plurality of sets of the multi-pass scans are included in the scans to be performed the scanning number of times, the generating of the print data includes setting the number of passes for each of the plurality of sets, and generating the print data such that the number of passes for the multi-pass scans to be performed in the final printing unit is the largest.

3. The apparatus according to claim **2**, wherein

the generating of the print data includes generating the print data that includes an increased number of the multi-pass scans with an increased number of passes.

4. The apparatus according to claim **3**, wherein the first ink is a white ink.

5. The apparatus according to claim **4**, wherein

the plurality of ink heads mounted on the carriage include:

a plurality of first ink heads configured to eject the first ink, the plurality of first ink heads being arranged side by side in the main scanning direction; and

a plurality of second ink heads configured to eject the second ink, the plurality of second ink heads being arranged side by side in the main scanning direction and in positions displaced from the plurality of first ink heads in a sub-scanning direction.

6. The apparatus according to claim **2**, wherein the first ink is a white ink.

7. The apparatus according to claim **1**, wherein

the generating of the print data includes generating the print data that includes an increased number of the multi-pass scans with an increased number of passes.

8. The apparatus according to claim **7**, wherein the first ink is a white ink.

9. The apparatus according to claim **1**, wherein the first ink is a white ink.

10. The apparatus according to claim **1**, wherein

the plurality of ink heads mounted on the carriage include:

a plurality of first ink heads configured to eject the first ink, the plurality of first ink heads being arranged side by side in the main scanning direction; and

a plurality of second ink heads configured to eject the second ink, the plurality of second ink heads being arranged side by side in the main scanning direction and in positions displaced from the plurality of first ink heads in a sub-scanning direction.

11. A non-transitory computer-readable medium storing computer-readable instructions, the instructions, when executed by a processor of a computer, performing processes comprising:

a determination operation determining a scanning number of times being a number of times that a printer carriage mounting a plurality of ink heads thereon is to be moved in a main scanning direction to form a single line image formed by a single dot array extending in the main scanning direction and having a width, in a sub scanning direction orthogonal to the main scanning direction, corresponding to a size of a nozzle formed in the ink head and to increase a maximum density of a first ink in the single line image to be higher than a unit density by ejecting the first ink a plurality of times to the single dot array, the printer carriage being provided in a printer the plurality of ink heads having at least one first ink head configured to eject the first ink, and at least one second ink head configured to eject a second ink, the one first ink head and the one second ink head being aligned along the sub scanning direction, the unit density being a density of a maximum amount of ink that can be ejected by moving the carriage once with respect to a single dot array; and

a generation operation generating, in a case where the scanning number of times is larger than a minimum value of a number of passes that can be set as a number of times of scans of a set of multi-pass scans, print data to cause ejection of the first ink and ejection of a second ink to be performed by the multi-pass scans in a final printing unit, among a plurality of scans to be performed a plurality of times equal to the scanning number of times, the set of multi-pass scans being a set of a plurality of scans in which, every time a scan is performed, an ink is ejected to the single dot array from a nozzle different from a nozzle used in a preceding scan, among a plurality of nozzles provided on each of the plurality of ink heads, the final printing unit being continuous scans corresponding to the number of passes including a last scan, among the scans to be performed the scanning number of times, and the second ink being an ink whose density is equal to or less than the unit density.

12. The non-transitory computer-readable medium according to claim **11**, wherein

in a case where a plurality of sets of the multi-pass scans are included in the scans to be performed the scanning number of times, the generation operation includes setting the number of passes for each of the plurality of sets, and generating the print data such that the number of passes for the multi-pass scans to be performed in the final printing unit is the largest.

13. The non-transitory computer-readable medium according to claim **12**, wherein

the generating of the print data includes generating the print data that includes an increased number of the multi-pass scans with an increased number of passes.

14. The non-transitory computer-readable medium according to claim **13**, wherein the first ink is a white ink.

15. The non-transitory computer-readable medium according to claim **14**, wherein

the plurality of ink heads mounted on the carriage include:

a plurality of first ink heads configured to eject the first ink, the plurality of first ink heads being arranged side by side in the main scanning direction; and

a plurality of second ink heads configured to eject the second ink, the plurality of second ink heads being arranged side by side in the main scanning direction and in positions displaced from the plurality of first ink heads in a sub-scanning direction.

16. The non-transitory computer-readable medium s according to claim **12**, wherein the first ink is a white ink.

17. The non-transitory computer-readable medium according to claim **11**, wherein

the generation operation includes generating the print data that includes an increased number of the multi-pass scans with an increased number of passes.

18. The non-transitory computer-readable medium according to claim **17**, wherein the first ink is a white ink.

19. The non-transitory computer-readable medium according to claim **11**, wherein the first ink is a white ink.

20. The non-transitory computer-readable medium according to claim **11**, wherein

the plurality of ink heads mounted on the carriage include:

a plurality of first ink heads configured to eject the first ink, the plurality of first ink heads being arranged side by side in the main scanning direction; and

a plurality of second ink heads configured to eject the second ink, the plurality of second ink heads being arranged side by side in the main scanning direction and in positions displaced from the plurality of first ink heads in a sub-scanning direction.

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